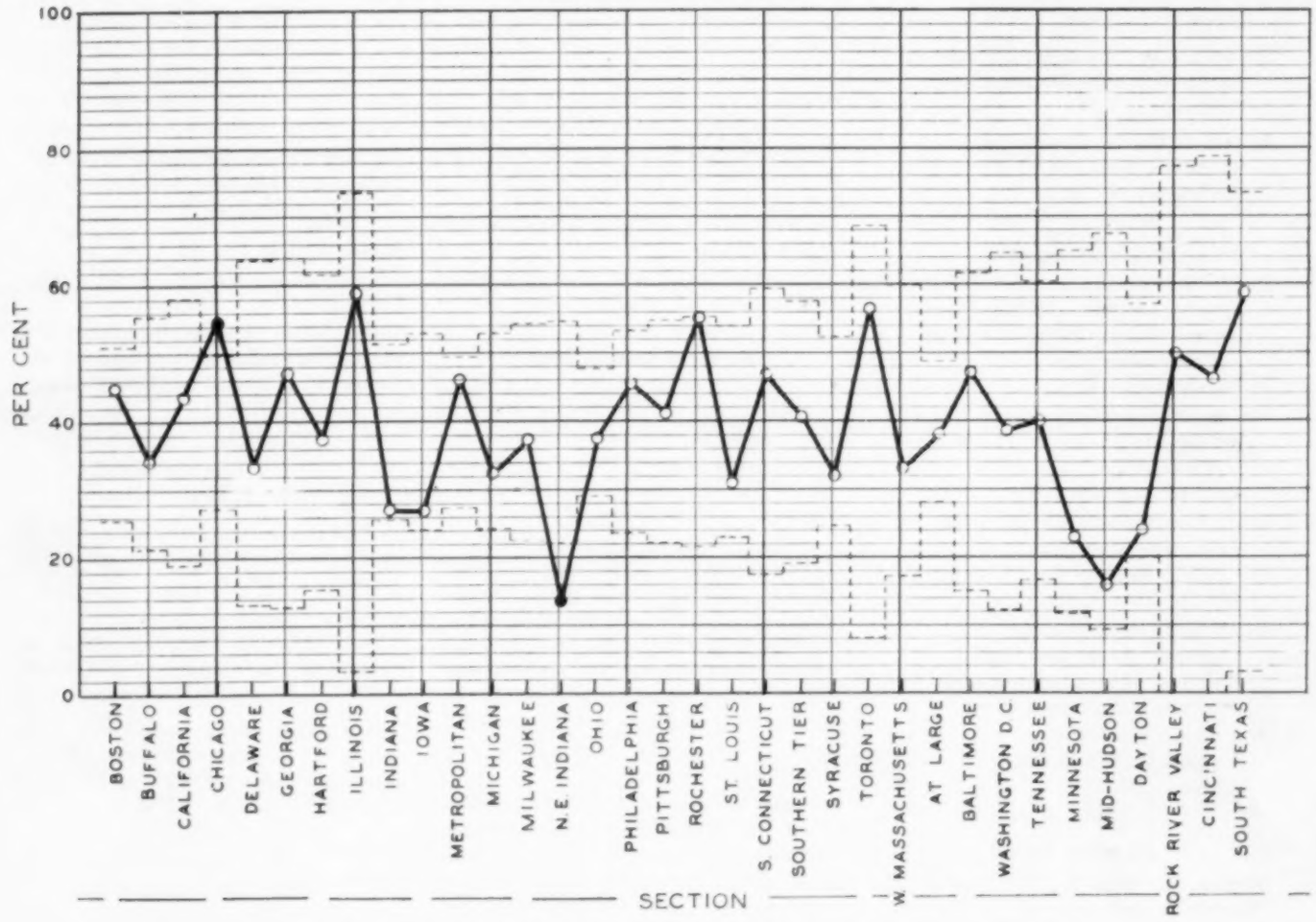
Industrial QUALITY CONTROL

VOL. VI SEPTEMBER, 1949 NO. 2

CONTROL CHART – ANNUAL A.S.Q.C. ELECTION – JUNE 17, 1949

PERCENTAGE OF MEMBERS CASTING BALLOTS



For the story behind this chart, see note by H. G. Romig, page 3

AMERICAN SOCIETY FOR QUALITY CONTROL

INDUSTRIAL QUALITY CONTROL

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* * *

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1949 ELECTION RETURNS

The Annual meeting of the American Society for Quality Control was held at the Engineering Societies Building on Friday, June 17, 1949. Its primary purpose was the election of officers for the ensuing year; ballots had previously been mailed to all qualified members. Slightly over 2,000 ballots were mailed out in 1948 while in 1949 2,563 ballots were mailed. The returns were very gratifying as 990 ballots or 38.5% were returned in 1949, whereas in 1948 728 ballots or 35.5% were returned. This indicates considerably more interest in national affairs by the increased membership this year.

The September 1948 issue presented a control chart covering the election in which one section was above the upper three sigma control limits. A similar chart on a large scale (30" x 40") was prepared and shown at the 1949 Annual meeting. This chart reduced is presented on the magazine cover. This year two of the sections were outside the control limits, Chicago being above its upper control limit having 49.8% of its 167 members turning in ballots, while Northeast Indiana was below its lower control limit having 13.6% of its 81 members turning in ballots.

In discussing the reasons why these two points should be outside control limits it was pointed out that the one below was probably due, among other possible causes, to the lack of a contested election. The one above was possibly due to a good publicity campaign or just due to the great interest the Chicago Section has always taken in the Society. The over-all increase in returns denotes a healthy condition. It is hoped that next year more members will use their ballots. A return of 50% or more is a good goal and would indicate to our hard-working officers that the Society members are 100% behind their efforts, and wish to express their confidence by voting.

TELLERS:

William A. MacCrehan, Jr.
Philip B. Proctor
David H. Schwartz
Charles J. Tantillo
Harry G. Romig, Chairman

ACKNOWLEDGEMENT

The art work for the chart on the cover of this issue was done by Miss Alice G. Loe of the Bell Telephone Laboratories. The art work for the chart similar to this on the cover of the September 1948 issue was done by Miss Suzanne Campbell, also of the Bell Telephone Laboratories.

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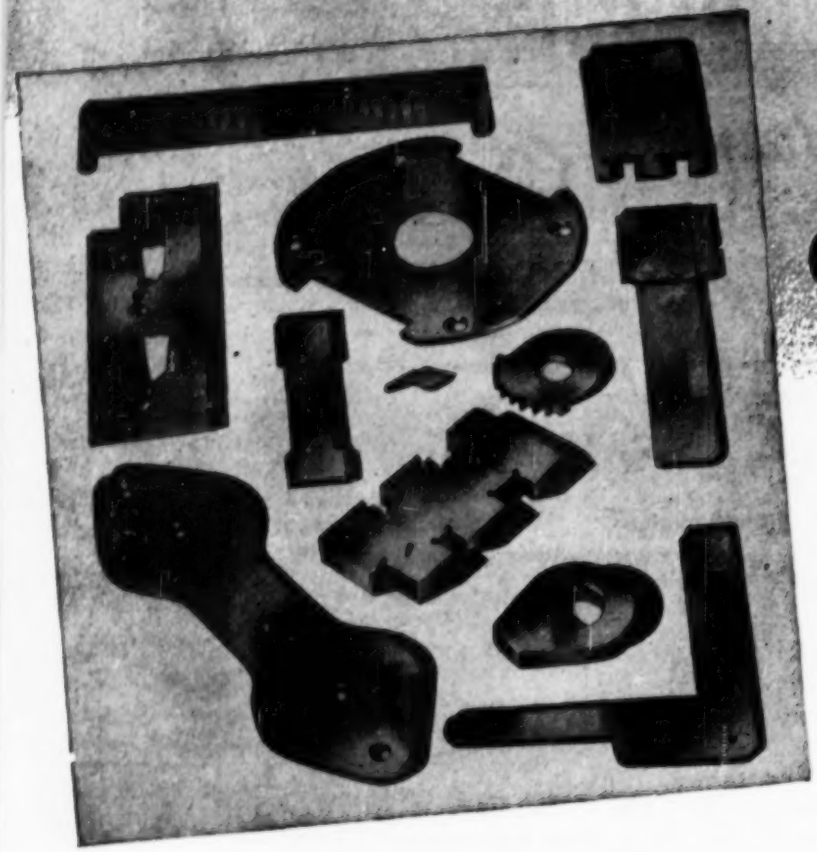

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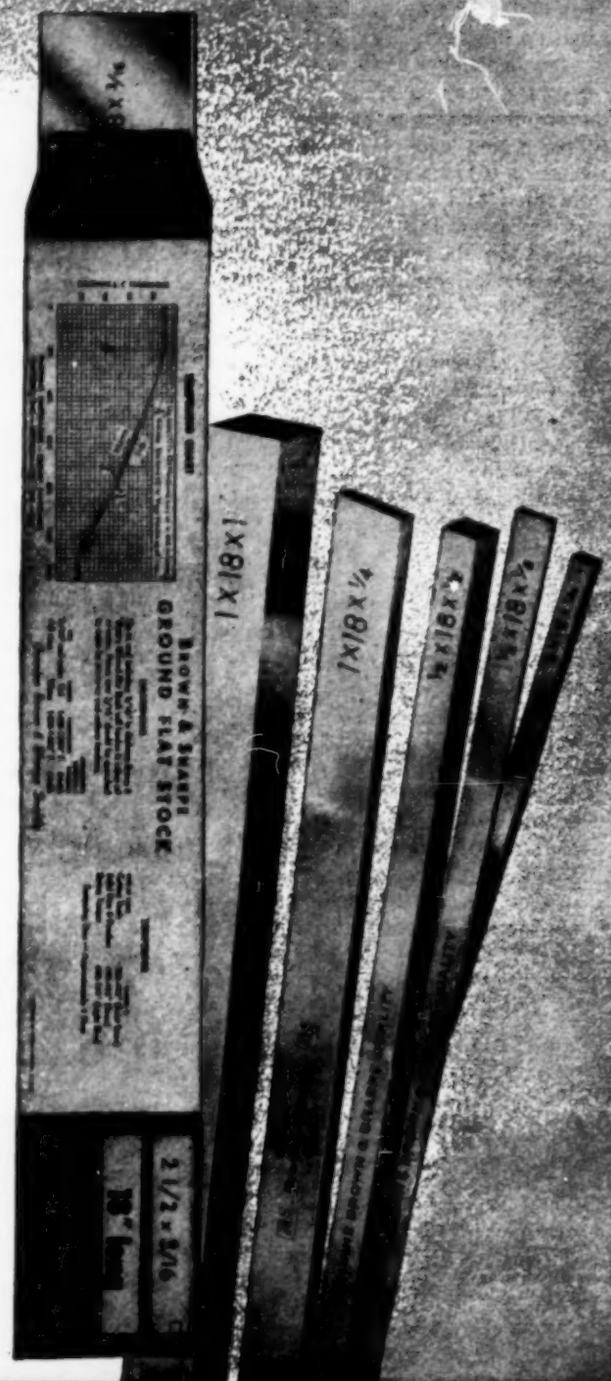

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Practical Applications of New Theory
A Review
PART I—LOCATION AND SCALE: TABLES

FREDERICK MOSTELLER
HARVARD UNIVERSITY

JOHN W. TUKEY
PRINCETON UNIVERSITY

EDITORIAL COMMENT

It is worth noting that the clinic session at which the material in this series of papers was presented attracted an attendance so heavy as to give convincing evidence that members of ASQC are genuinely interested in getting acquainted with the latest statistical techniques applicable to the quality control field. Publication of these papers in IQC makes this information readily accessible to all members of the Society. Parts II, III, and IV will appear in subsequent issues.

Many statistical developments are not used in practice until long after their discovery. Sometimes this happens because the material is written in difficult mathematical language which most users do not have the time or equipment to translate. In other cases the developments are published in journals not ordinarily read by the potential users. For example, a general development in statistics may be published in a journal for geneticists in an article about specialized flora — quality control people are not likely to be aware of such a result. Quality control people have been quick to apply the latest methods which have been brought to their attention, and they frequently ask for and need new and different tools to help solve their more specialized problems.

These articles, of which this is the first, are based on a report made to the Third Annual ASQC Convention at Boston in May 1949. They were prepared to bring to the attention of quality control personnel some of the latest developments in mathematical statistics which, in the opinion of the authors, may be usefully applied in quality control work. It must be remembered that most of the material discussed has not been used extensively in practice, and that any one person will rarely have frequent use for very many of these devices—some of the material is for treating rather specialized problems. Most of these developments have appeared in articles on mathematical statistics, and their application to quality control work has usually not been specifically mentioned.

It would be a mistake, however, to assume that mathematical developments have not grown out of quality control. It will be seen in later parts that some of the mathematical developments have been made by research men in the quality control field who were working directly on quality control problems. One example of this is the field of process control.

We are going to discuss those of the developments since 1940 which seem most interesting, and have not been reviewed on their own account. Thus we omit the extensive work on sequential analysis and run theory.

The present paper covers (i) "quick and dirty" methods for estimating means and standard deviations in moderate and large samples, (ii) quicker substitutes for Student's t test, (iii) a list of some recent useful statistical tables which extend the scope of the customary tables.

"QUICK AND DIRTY" ESTIMATION PROCEDURES

A.E. Jones ["A useful method for the routine estimation of dispersion in large samples," Biometrika 33 (1943-6) 274-282] has pointed out the advantages of estimating dispersion in terms of the largest and smallest observations in a sample. This procedure is a generalization of the use of the range, that is of

(Largest one) — (Smallest one),

which is known to be good in small samples and poor in large. Jones proposes to use

(Sum of r largest) — (Sum of r smallest).

He shows that very little is gained by making r greater than 4% of the size of the sample. (This would mean using the range for samples of less than 13, which is quite reasonable.)

Working on the same principles, Randal H. Cole ["An r-ply range estimation of mean and standard deviation," Memorandum Report 20, SRG Princeton University, 1949] gives more detailed tables for Jones estimate of the standard deviation of a normal population, covering samples up to 200 for various values of r. He points out that, for any symmetric distribution, the mean is estimated by

Average of r largest and r smallest,

and, of course, no further computation is needed. Cole points out that these methods can result in savings especially when the cost of measurement is high and it is possible to isolate the extremes of the population readily without having to measure the mass of cases concentrated at the middle of the population. For example, parts may be sorted automatically or by go, no-go gauges into three or more groups. Then it would be possible to measure only the members of the extreme groups and apply the methods of Jones and Col . Of

course, one might also use the gauge methods of estimation, but since these have already appeared in the quality control literature we shall not discuss them here.

In destructive testing, it may be profitable to obtain only the r smallest values. We shall return to this in a later part.

A third situation, not quite so common in quality control, occurs when a great deal of data has been amassed and cannot easily be broken into rational subgroups and where the temporal order is lost or meaningless. In such cases Mosteller ["On some useful 'inefficient' statistics," Annals of Math. Stat. 17 (1946) 377-408] has proposed the use of judiciously selected members of the sample for estimating the mean and standard deviation of the normal. It is well known that the median is about 64% efficient* for estimating the mean. It is not so well known that the average of the two observations 25% in from the ends of the sample is 81% efficient and that the average of 3 well-chosen observations can be 88% efficient. The efficiency of the range for estimating the standard deviation gets poorer and poorer as the sample size increases, but the use of the quasi range divided by a constant:

$$\frac{\text{(93 percentile — 7 percentile)}}{3.624}$$

maintains an efficiency of about 65% even for large samples (for small samples it is much better). This result is due to Karl Pearson. Results for other estimates are given in Mosteller's paper as well as a treatment of the correlation coefficient.

SUBSTITUTES FOR STUDENT'S t AS APPLIED TO ONE MEAN, OR TO TWO MEANS FROM PAIRED SAMPLES

Various authors have discussed rapid substitutes for Student's t in stating probability limits for the mean of the populatio. for which a sample has been drawn. All these rapid substitutes are based to a greater or less degree on the values of the observations falling in a particular place when the sample values are arranged in increasing order of size. Some have emphasized their constancy of behavior as the shape of the population changes. Although Student's t is derived mathematically on the assumption of a normal distribution, the usual deviations from normality do not affect the usefulness of t appreciably. (The one exception is one-sided tests on very skew distributions, where the substitutes also break down.) All these tests apply both to comparing one sample with a contemplated value for the population mean and to comparing two samples where the observations are paired. For simplicity we shall phrase all our discussion in terms of comparing one sample with a contemplated value, although some of the tests are explicitly stated for the case of paired samples. (A set of pairs, one observation in each obtained under conditions A and under conditions B, can always be reduced to one sample by taking differences. When conditions A and B are indistinguishable, the distribution of the differences is symmetric; thus there is never any difficulty with skewness.)

These tests are usually directly useful for samples of moderate size, say at most 20. The first of these to be discussed recently was the ratio

$$\frac{\text{Sample mean — Contemplated mean}}{\text{Sample range}}$$

which has been proposed by H. F. Dodge ["Statistical control in sampling inspection," American Machinist 76 (1932) 1130] and Lila F. Knudson ["A method for determining the significance of a shortage," Jour. Am. Stat. Ass'n. 38 (1943) 466-470] This was discussed by Joseph F. Daly ["On the use of the sample range in an analogue of Student's t-test," Annals of Math. Stat. 17 (1946) 71-74] who pointed out that this ratio was nearly as efficient (powerful) as Student's t. A more complete study was made independently by E. Lord ["The use of range in place of standard deviation in the t-test," Biometrika 34 1947) 41-67] who gives extensive tables of significance levels for samples up to 20. Lord's work is also distinguished by a study of the case where the average range of two or more rational subgroups can be used.

A further modification has been discussed by John E. Walsh ["On the range-midrange test and some tests with bounded significance levels" Annals of Math. Stat. 20 (1949) 257-267], who gives full tables, namely the use of

$$\frac{\text{Sample midrange — Contemplated mean}}{\text{Sample range}}$$

This ratio was first studied by Egon S. Pearson ["The distribution of frequency constants in small samples from non-normal symmetrical and skew populations. 2nd paper.", Biometrika 21 (1929) 259-286, especially 280-285] who showed that for samples of more than 10 the use of this ratio was definitely inferior to the use of Student's t. Walsh's work has shown that this ratio is quite effective in smaller samples.

The next class of test is due to Frank Wilcoxon ["Probability tables for individual comparisons by ranking methods," Biometrics 3 (1947) 119-122 which contains full tables; "Individual comparisons by ranking methods," Biometrics Bulletin I (1945) 80-83; "Individual comparisons of grouped data by ranking methods," Jour. Econ. Entomology 39 (1946) 269; and a pamphlet "Some rapid approximate statistical procedures," issued in several editions by the Insecticide and Fungicide section, American Cyanamid Company, Stamford, Conn.]. In this test the n values of

$$\text{Observation — Contemplated mean}$$

are ranked in order of magnitude (without regard to sign) and then the sign of the difference is attached to the rank. Thus when observed values of 57, 53, 47, 61, 65, and 69 are compared with a contemplated value of 54 they yield differences of 3, —1, —7, 7, 11, and 15, whose ranks are 2, 1, 3.5, 3.5, 5, and 6, and whose signed ranks are +2, —1, —3.5, +3.5, +5, and +6. The sum of the positive signed ranks is $+2+3.5+5+6 = 16.5$, and of the negative signed ranks is $1+3.5 = 4.5$. Since neither of these sums is 1 or less (which is the 5% limit for six observations) the contemplated value 54 is not rejected by the data. This procedure is simple and efficient for samples up to 20, and the necessary significance levels are given by Wilcoxon.

The connection of Wilcoxon's test to another class of tests recently introduced can be shown [John Tukey, Memorandum Report No. 17, SRG Princeton University, 1949] by returning to the example 57, 53, 47, 61, 65, and 67 and writing down the averages of all possible pairs (including the result of pairing each observation with itself). This yields 57, 55, 52, 59, 61, 62, 53, 50, 57, 59, 60, 47, 54, 56, 57, 61, 63, 64, 65,

* See NOTE 1, p. 8

66, 67. The two largest are 67 and 66, the two smallest are 47 and 50. (Two are taken because two is one more than the 5% significance level of 1 in the Wilcoxon test.) Then a 95% confidence interval for the population mean runs from 50 to 66. This direct method of calculation is feasible for sample sizes up to 12 or 13.

The rephrasing of Wilcoxon's test shows that it belongs to a class of tests recently studied by Walsh ["Some significance tests for the mean which are valid under very general conditions," Annals of Math. Stat. 20 (1949) 64-81], who has considered tests based on certain order statistics, on averages of two order statistics, and on combinations of these. For sample sizes of 6 to 15, and for reasonable selections of significance levels, there are tests of this sort. The most interesting thing is their insensitivity to certain sorts of misbehavior of the population. *Each* observation in the sample can be drawn from a *different* population, so long as these populations are all symmetric about a *single* point, which is their common median. Confidence limits can be calculated more simply in samples of 10 to 15 by the tests given explicitly by Walsh than by Wilcoxon's procedure, and while Walsh's tests are probably not so efficient as Wilcoxon's tests, their efficiency (for normal populations) is over 90%.

The important pros and cons of all the substitute tests seem to be:

Against the substitutes

No one method for all sample sizes.

For the substitutes

Less computation than for Student's t.

The matters of efficiency and insusceptibility to non-normal seem to be small and unimportant.

There are three alternatives which seem particularly reasonable:

ALTERNATIVE A

Always use the t-test.

ALTERNATIVE B

In samples up to 20 use Mean/Range and Lord's [Biometrika 34 (1947) 66] tables.

In samples of more than 20, use Mean/Range on medians of rational subgroups when available; otherwise revert to the t-test.

A slight further saving in computation for samples of 2 to 7 can be made by using Table 1. If the largest and smallest values in a sample of six are 13 and 6, then the range is 7, and 98% two-sided confidence limits for the population mean are:

$$13+(.06)7 = 13.42,$$
$$6-(.06)7 = 5.58,$$

while 95% two-sided confidence limits are

$$13+(-.07)7 = 12.51,$$
$$6-(-.07)7 = 6.49.$$

This table is based on Walsh's Table 5.

TABLE 1

Factors based on Midrange/Range

Sample Size	Two-sided limits 10%	5%	2%	1%
2	2.56	5.85	15.41	31.33
3	.40	.80	1.61	2.52
4	.06	.24	.54	.87
5	—.08	.02	.21	.35
6	—.15	—.07	.06	.16
7	—.20	—.12	.02	.05
	5%	2.5%	1%	.5%
	One-sided limits			

To illustrate the situation with more than 20 cases mentioned in Alternrative C we take data on blowing time of fuses [American Standards Assn. Z1.3 (1942) 22-3]:

Blowing time of fuses (sets of five)

Set	1	2	3	4	5
	42	42	9	36	42
	65	45	24	54	51
	75	68	80	69	57
	78	72	81	77	59
	87	90	81	84	78

The medians are 75, 68, 80, 69, 57; the range of these medians is 80—57 = 23. Then 95% confidence limits for the mean blowing of fuses in the lot are

$$80 + (.02)23 = 80.46$$
$$57 - (.02)23 = 56.54.$$

ALTERNATIVE C

Sample Size	Testing one Value	Setting Confidence Limits	Comparing two Groups of Paired Values
2 to 7	$\frac{\text{midrange}}{\text{range}}$ (1)	$\frac{\text{midrange}}{\text{range}}$ (1)	$\frac{\text{midrange}}{\text{range}}$ (1)
8 to 10	signed ranks (2)	signed ranks (2)	signed ranks (2)
11 to 15	signed ranks (2)	Walsh tests (3)	signed ranks (2)
16 to 20	signed ranks (2)	See below	signed ranks (2)
more than 20	Use methods above on medians of rational subgroups when available, otherwise revert to the t-test		

(1) Tables in Walsh [Annals of Math. Stat. 20 (1949) 261, or see below]

(2) Tables in Wilcoxon [Biometrics 3 (1947) 119-122, or pamphlet]

(3) Tables in Walsh [Annals of Math. Stat. 20 (1949) 66-67]

SOME EXTENSIVE AND USEFUL TABLES

NOTE: Hald 1948, refers to the tables accompanying "Statistike Metoder" by A. Hald, Det Private Ingeniørfond, Copenhagen, 1948; an English translation will, we believe, be issued by Wiley.

Student's t

Merrington Biometrika 32 (1941-2) 300
Baldwin Biometrika 33 (1943-6) 362

Chi-Square

Thompson Biometrika 32 (1941-2) 187-191
Hald 1948, Table V (See NOTE above)

Chi-Square/Degrees of Freedom

Hald 1948, Table VI (See NOTE above)

F = Variance-Ratio

Merrington and Thompson Biometrika 33 (1943-6) 73-88
Hald 1948, Table VII (See NOTE above)

Range

Hartley Biometrika 32 (1941-2) 309-310
Hald 1948, Table VIII (See NOTE above)

Studentized Range

Pearson and Hartley Biometrika 33 (1943-6) 89-99

Mean Deviation

Hartley Biometrika 33 (1943-6) 259-265

Homogeneity of Variances

Thompson and Merrington Biometrika 33 (1943-6) 296-304

Binomial Confidence Limits

Hald 1948, Table XI (See NOTE above)

Angular Transformation

Hald 1948, Table XII (See NOTE above)

NOTE 1

"Efficiency" measures the extent to which the observations are "milked" of the information they contain. The relative efficiency of two competing statistical processes is usually taken as the reciprocal of the ratio of the sample sizes in which they give equivalent results. Thus, if one process requires 20 observations to do what another process, perhaps requiring more arithmetic, can do with only 13 observations, the relative efficiency of the first process is $13/20 = 65\%$. The absolute efficiency of a statistical process is its relative efficiency compared to the most efficient competitive process.

In this definition, equivalent estimates are estimates which have the same variance, and equivalent tests are tests which, thought of as acceptance sampling plans, have the same operating characteristic, or operating characteristics matched "on the average."

The Scope of Quality Control

WARREN R. PURCELL

SYLVANIA ELECTRIC PRODUCTS, INCORPORATED

INTRODUCTION

In its broad sense, the science and art of quality control is an essential element of successful manufacturing and, as such, is as old as manufacturing itself. Yet it is only recently emerging as an apparently separate profession.

Among the reasons for this phenomenon was the intense need for improved quality control during World War II. Because of this, there was a groping for "something new." The "something new" was provided by certain technical refinements of inspection and trouble shooting methods, often called "Statistical Quality Control." "Statistical Quality Control" has proved itself to be a powerful tool in almost every phase of the broad function of quality control. It provides a "way of thinking" in terms of variability and probability. It provides scientific guides to minimize various kinds of errors, such as improper setting of standards and tolerances; shooting for trouble when no trouble exists, or, conversely, not shooting for trouble when trouble does exist; and being fooled too much too often by the element of chance in sampling, or, conversely, sampling uneconomically.

Because of the recent growth in the use of these technical refinements, there is a tendency in some instances to regard quality control itself as something new, or as something to be "installed" in a going plant. Such a statement would seem to be misleading unless the expression "statistical quality control" is used. Even then, it would hardly seem that statistical quality control is "installed," but rather that those responsible for controlling quality begin to use more and more of this comparatively new "way of thinking" in the solution of their quality control problems. In most industrial plants there is much room for improvement by the use of this new "way of thinking." As a broad function, however, quality control is an essential element of good manufacturing management, and any industrial organization which is competing successfully today must have had quality control in fairly successful form since it was founded, otherwise it could not compete successfully.

Perhaps, in view of this situation, it is in order for some of us who are devoting our time to this comparatively new profession to begin to define the areas in which it operates and just what seems to be the scope of the function in which we are engaged. The following is an attempt to do this in view of our experience with quality control at Sylvania.

Quality Control, in our thinking, is a broad function which is closely related to many other functions in manufacturing including Purchasing, Engineering, Production, Personnel, Inspection, and Sales. It fosters the inter-dependence and mutual helpfulness of these otherwise somewhat independent functions.

Quality control fosters this mutual helpfulness by means of three broad services. The first of these is the thoughtful, scientific, and practical approach to the problems of quality standards, not only for finished products, but also for raw materials, equipment, and work in process. The second is through improvements in the function of detecting deviations from these standards accurately,

effectively, and economically. The third is through improvements in the techniques of locating the causes of these deviations.

In extending these services for the setting of quality standards, detecting deviations from them, and locating the causes of the deviations, quality control uses three broad classes of techniques: administration, engineering, and statistical. There are, therefore, nine areas in which quality control assists the other functions in attaining and maintaining better quality, greater quantity, and lower cost. These nine areas are represented by the intersections of the three services and the three classes of techniques as indicated in the accompanying diagram.

	Setting of Quality Standards	Detection of Deviations	Location of Causes
Administrative	**Area 1** Economic Quality Balance	**Area 4** Inspection	**Area 7** Know-How
Engineering	**Area 2** Tolerances	**Area 5** Measurement	**Area 8** Design of Experiments
Statistical	**Area 3** Process Capabilities	**Area 6** Control Charts and Sampling Plans	**Area 9** Variance and Correlation

AREA 1

This is the use of administrative techniques in the setting of quality standards. It is an attempt to determine the economic quality balance, or, to borrow an expression from Dr. J. M. Juran, the best balance between the cost of quality and the value of quality. In some cases, this objective can be determined fairly accurately; in other cases, only estimates can be made. In all cases, however, true facts must be found and careful interpretation of those facts is essential. Upon a good evaluation of this balance the whole economy of quality control depends.

The determination of the best balance must begin with the finished product. In those cases where the finished product goes to a customer who accurately specifies the quality standards he needs by indicating at what point the quality becomes so poor it is not acceptable to him, the best balance can be determined fairly accurately—it is simply a quality level such that rejections will be very rare. In those cases where the customer does not so specify, the best balance must be estimated. The accuracy with which the estimate can be made is increased by knowledge of the way in which the customers use the product, how they expect it to perform, whether they regard the present quality level favorably or unfavorably, the number of true quality complaints being received, and the quality level being maintained by competitors. In this area the quality control man must be able to work effectively with the Sales, Sales Engineering, and Sales Research groups.

After the best balance for finished products has been determined, the next step is to determine the best balance for materials, equipment, and work in process, in order to determine how to maintain the finished product quality objective most economically. The problems here break down into two fields: those deviations which are likely to be detected during processing or in the final inspection of finished products, and those deviations which are likely to go undetected and adversely affect the quality of the product which reaches the customer. In the first field the determination of the best balance is not difficult. It is a simple case of balancing the cost of inspection of materials, equipment, or work in process against the cost of rejections after additional processing has been done. In the second field there is a two-fold problem. The first is a determination of the extent to which early deviations will affect finished product quality. The second is a balancing of the cost of detecting those deviations against their adverse effects on final quality. If the final quality objective has been accurately determined by customer specifications, there is little choice—the important early deviations *must* be detected. If the final quality objective has been estimated, it might be worth while to revise the estimate in view of the cost of detecting early deviations.

AREA 2

This is the use of engineering techniques in the setting of quality standards. It covers the entire field of tolerances. Tolerances are applied to materials, equipment, work in process, and finished products. Tolerances, in the broad sense, apply not only to such items as dimensional, electrical, chemical, special mechanical and other measurements; but also to less well-defined items such as color, finish, strain patterns, tool marks, burrs, chips, etc.

In mass production, modern tolerances are applied not only to the individual units of product, but also to the lot which consists of many units. Quality is specified completely when the specifications not only define the limits for the unit, but also the lot size and percent of out-of-tolerance units to be tolerated in the lot, or the percent of out-of-tolerance units to be tolerated in the long run.

In applying these engineering techniques, tolerances must be definite but they must not be determined arbitrarily. Consideration must be taken of the best balance between the cost of quality and the value of quality as determined in Area 1, and of the uniform capabilities of the established processes as determined in Area 3.

In this area of quality control operations, there is a vast and almost visionary field for those industries in which assembly tolerances are important. By applying the "natural" tolerances to the various parts of such assemblies, and by controlling the processes to those "natural" tolerances, it is possible to take advantage of the important theorem that tolerances can be added as the square root of the sum of the squares rather than by simple arithmetic addition. This is an important step forward in the principle of interchangeability of parts rather than selective assembly. This can effect great economies in operation accompanied by improvement in quality. It can be thought of as the second step in the development of interchangeability of parts, the first important step of which was taken by Eli Whitney in the manufacture of guns.

AREA 3

This is the use of statistical techniques in the setting of quality standards. It is based on the measurement of the degree of uniformity which a given process is capable of maintaining. The approach is based on a recognition of the fact that variability exists in every repetitive operation. There are, however, two distinct types of

variability. One type of variability is inherent in the process. It is caused by a very large number of small causes, each of which is too small to be clearly identified. Typical of such causes is slight vibration in floors, small amounts of bearing play, small errors of observation, etc. These small causes usually act independently and are so small that their combined effect follows the law of chance. Their effect can usually be reduced only by making major changes in the manufacturing process, and many times such major changes are not economically justifiable.

The other type of variability is not inherent in the process, but is the result of some other dominant cause, such as a wrong setting, loose bearing, mistake in measurement, etc.

By means of "control sampling" and statistical analysis of data, it is possible to separate these two, and thus to get a measurement of the inherent variability alone. This inherent variability should always be considered in setting tolerances for it establishes the "natural" tolerances referred to above.

AREA 4

This is the use of administrative techniques in the detection of deviations from standards. It is the inspection function itself. In order that deviations will be detected accurately, economically, and effectively, the inspection department should be given the same thorough managerial attention as the production department. The man at the head of this department should be thoroughly competent as an organizer and administrator, as well as technically competent. As a good reporter has a "nose for news" and a good salesman has a "nose for business," he should have a "nose for trouble."

The literature contains many thoughts and suggestions indicating how the various functions of inspection, engineering, production, etc., should be related on the organization chart. Experience indicates, however, that the persons involved are usually a more important consideration than the organization chart which is put on paper. In any case, however, there seems to be little disagreement with the thought that final inspection should not be subject to undue influence from the manufacturing personnel whose objective usually is to get maximum quantity, nor from the engineering personnel, since inspection should be independently free to criticize engineering.

In many inspection departments there is a big field of opportunity for the development of automatic inspection with its attendant efficiency and freedom from human errors of judgment. It should be kept in mind, however, that automatic inspection equipment can get out of adjustment just as much as automatic manufacturing equipment and that some sort of check inspection after automatic inspection should be provided.

AREA 5

This is the use of engineering techniques in the detection of deviations from standards. It involves the entire field of measurement. It includes the design of mechanical gages and electrical test equipment, chemical analysis, optical and photometric measurement, hardness testing, tensile strength and fragility tests, etc. The list is almost endless. Engineering has made great strides in increasing the scope of our ability to measure. But the horizon seems to be without limit. There are still many slips in quality which go undetected because we lack an adequate method for measuring the characteristic which changed.

AREA 6

This is the use of statistical techniques in the detection of deviations from standards. It involves the use of the principles of variability and probability. It covers the field of the control of processes by distinguishing excessive variability, which is due to "assignable" causes, from inherent variability, which is due to "unassignable" causes. It covers the field of the acceptance or rejection of lots by the inspection of samples drawn from the lots.

In the control of processes the most valuable statistical tool is the control chart developed by Dr. Walter A. Shewhart. By means of control charts it is possible not only to distinguish between inherent variability and excessive variability, but also to shed light on the pattern of the behavior of the process, which is a valuable aid in locating the causes of the deviations.

In the field of acceptance or rejection of lots by sampling, statistical methods provide the scientific answers to such problems as sample size and acceptance criteria. These are vital considerations in determining the best balance between the cost of quality and the value of quality. Once this best balance has been determined, scientific sampling maintains the balance; on the one hand by avoiding too many wrong decisions because of the element of chance, and on the other hand by avoiding the high cost of excessive inspection.

AREA 7

This is the use of administrative techniques in locating the causes of deviations from standards. It is inseparable from the job of making things. It is the area of quality control which is most closely associated with production.

The first requirement here is quality-mindedness on the part of top management. Through this quality-mindedness are developed many of the factors which contribute toward both efficient manufacturing and the positive and continuous control of quality. Among the factors of importance to quality control in this area are good employee selection, training, and supervision programs, and the maintenance of a quality atmosphere by efficient plant layout, good housekeeping, and up-to-date methods.

In addition to these general approaches to quality control, it should be recognized specifically that in any organization there are men who are skillful in locating causes of trouble. Their skill has been attained through experience and resultant familiarity with the process. They have learned how to find causes simply because those causes have previously been the sources of the same troubles. They are the men with the "know-how" of the process. They may be known as foremen, factory engineers, patrol inspectors, trouble shooters, or by any other title. For a large number of the deviations which occur, such men are usually able to find the causes more quickly than any other men, however well-informed about systematic engineering and statistical methods. The administrative technique is the locating of such men in the organization in such a way that their skill can be used to full advantage. It is also important to keep them properly motivated, and to assure continuity by grooming understudies to replace them when necessary.

AREA 8

This is the use of engineering techniques in locating the causes of deviations from standards. It takes over where Area 7 leaves off. It is the systematic investigation of causes to be used when a problem does not yield to the factory know-how.

For such investigations experiments are conducted. The usual attack is to make an "educated guess" as to the cause, and then to run a test deliberately varying the suspected cause, while

"holding everything else constant." Often such experiments are successful in finding the cause. Too often, however, they either indicate a cause which is not real or is, at best, only one of several causes. Sometimes an experiment fails to indicate a cause which is nonethe-less real. Sometimes the data present evidence which is so conflicting that no valid conclusions can be drawn. The fallibility of persons and the perversity of inanimate objects are often at work to render such experiments erroneous or inconclusive.

These difficulties can be prevented by randomizing. The technique of randomizing is based on the realization that it is always impossible, and sometimes undesirable, to eliminate the effects due to causes other than the one being investigated. By randomizing, these extraneous effects are neutralized rather than eliminated.

Randomizing not only eliminates the confounding of experiments, but also makes possible the design and execution of comprehensive experiments in which the effects of several causes can be studied simultaneously, thus saving large amounts of duplication of experimental effort. In this technique the effects due to unknown causes are neutralized, and each set of causes is free of any confounding of the results due to the other known causes which are being simultaneously investigated.*

AREA 9

This is the use of statistical techniques in locating the causes of deviations from standards. It is the systematic analysis of the data from experiments such as those referred to in Area 8.

The systematic analysis assists in the decision whether the data from the experiments indicate true correlation of suspected cause with observed effect, or whether the observed effect might have been due to other causes, and cannot, therefore, be conclusively attributed to the suspected cause. Such an analysis is the last line of attack on the problem of correlating cause and effect.

* See, for example, L. A. Seder "The Technique of Experimenting in the Factory," Industrial Quality Control, March 1948, p. 6.

CONCLUSION

In the foregoing outline of the field covered by quality control, no attempt has been made to indicate where it should fit in the organizational structure. This is intentional, for the areas described cover many of the jobs which were being done long before we recognized quality control as a separate profession. From this standpoint then, it hardly is an independent responsibility, but rather an advisory coordination of efforts in jobs already being done. Whether it should be set up as a direct line function with well-defined responsibilities or as a staff function with only service, advice, and coordination activities is a decision which will probably vary from company to company. In any case, however, the important point is to recognize that modern quality control can be extremely helpful in these various areas, and that a program for using the techniques to full advantage is one which should extend at least over a period of many years, and probably for the entire life of the company.

Use of Control Chart Techniques in Making a Quality Audit†-Part II

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In Part I of this paper we showed how engineering data, collected by dismantling small regular samples of completed product, and studied with the aid of control-chart techniques (1, 2), may reveal the presence of unsuspected quality deviations, add to the store of engineering knowledge, and provide a powerful stimulus and aid to the achievement of optimum control. There are other effects also, some of which will be described in the part which follows.

Such an audit, for example, may lead to a desirable reduction of the process variability. The following case is an illustration of this effect.

CHARACTERISTIC C

Figure 9 shows part of the history of Characteristic C. Like Characteristics A and B, which were treated in Part I, this is an important internal dimension in our transmission instrument of Type X. Again the chart covers a period of a little more than a year, during which we have taken 200 samples of five.

Throughout that period Characteristic C was found to be in good statistical control. This is shown by the fact that neither range nor average points have any tendency to move beyond the 3-sigma control limits. But prior to point X, although the process was controlled, it was not compatible with the specification. That is to say, the range or spread of the process was too great, so that the product flowing from it would spread out wider than the limits which must be met.

This excessive variability in the process is shown in the following way: The average range of our samples was approximately 4 units. This was higher than a certain "critical range"*, marked by an arrow in the lower margin, which in this case was very close to 3. Under

† Part I of this paper was published in the July 1949 issue of I.Q.C.

* Value such that 6σ or $6\bar{R}/d_2 =$ specified tolerance, where $d_2 = 2.326$ for samples of $n = 5$. See (2).

these conditions, if we assume a nearly normal distribution, something like 2% of the parts were bound to be defective; attention is directed to that fact by heavy lines, outside of the tolerance limits, whose location shows how far the individual parts will spread if the process is centered around the engineering mean. On the original chart, as mentioned in Part I, these warning lines are drawn in red.

It will be recalled that a similar situation was observed for a time in Characteristic B. But there the condition was obviously abnormal, and was recognized as trouble by all concerned; whereas in the present instance it appeared to be an accepted characteristic of the process, which existed in spite of the usual shop controls.

REDUCTION OF TOTAL VARIABILITY

It sometimes happens that when a process is in statistical control, with its values centered around the engineering mean, the Shop's individual controls may furnish little incentive to further action. This is particularly true if the percent defective is fairly low, and if the parts are being made at a number of different positions or machines. Conformance charts (3) on individual lots are apt to look like those in Figure 10. A sharp eye, or non-parametric tests (4), or some simple computations will reveal significant deviations from standard; but it is easy to assume that such departures are minor and temporary in nature, or associated with isolated lots. Sampling plans (5) also are applied to individual lots, some of which may be rejected or detailed. But a chart of the auditing type, reflecting the total product, may show that the pattern of variation from lot to lot proceeds from an overall system of causes; and that this pattern may be statistically stable, and yet not meet the intent of the design.

Charts like Figure 9 are apt to provoke lively discussions between the Shops, the tool maintenance people and the product engineers. Not infrequently, as a result of these, it is found that the existing system of causes can be changed — even, perhaps, without an appreciable effect on cost. In the case of Characteristic C, for instance, the Shop made many small improvements all along the line. There were closer controls at the machines, more uniform settings at multiple tool positions, better methods of chucking and handling the parts. Through the cumulative effect of all these things, the average

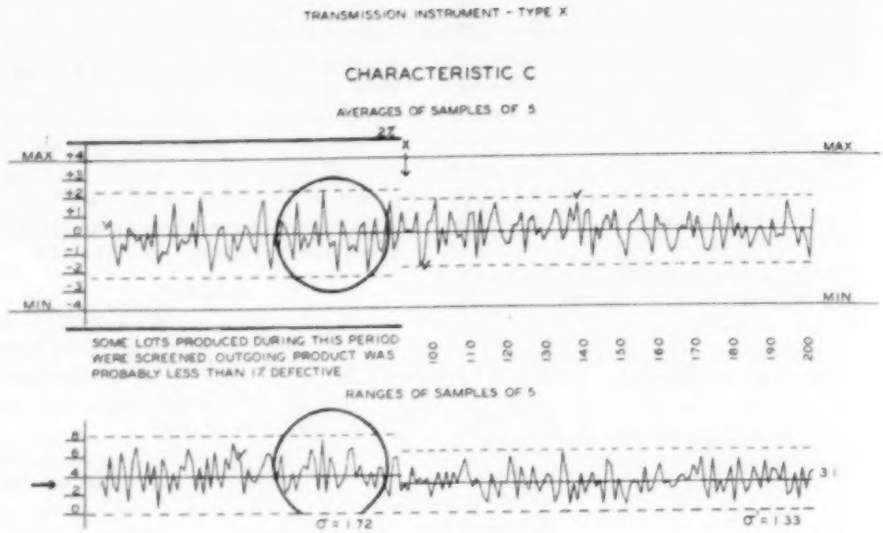
TRANSMISSION INSTRUMENT - TYPE X
CHARACTERISTIC C
AVERAGES OF SAMPLES OF 5
MAX
MIN
SOME LOTS PRODUCED DURING THIS PERIOD WERE SCREENED. OUTGOING PRODUCT WAS PROBABLY LESS THAN 1% DEFECTIVE
RANGES OF SAMPLES OF 5
σ = 1.72
σ = 1.33

FIGURE 9—CHARACTERISTIC C

range of our samples was reduced from 4 units to 3, and the product has continued to show a satisfactory conformance-control.

CHARACTERISTIC D

A control-chart audit may, on the other hand, lead to the establishment of realistic tolerances, in cases where it is not considered practical or economic to improve the process further. An example of this is Characteristic D.

Figure 11 shows that this process also was unsuited to its limits, which were specified as ± 2. Note that again the average range of our samples was higher than the arrow in the margin which marks the critical range. But here the incompatibility was more serious than in the case of Characteristic C. The chart predicted that 5% of product would be defective, even if the process average could be held at the enginering mean; and the Shop was compelled to control the outgoing product by constant screenings and rejections.

At the beginning of our study, prior to point A, many of the ranges had been excessively high, and certain assignable causes had been discovered and removed. But when all reasonable efforts had been exhausted, the remaining variability, as shown between points A and C, was still greater than the tolerance would permit. Furthermore the Shop, in attempting to avoid rejections, kept shifting the process average first in one direction and then in the other, thereby unconsciously increasing

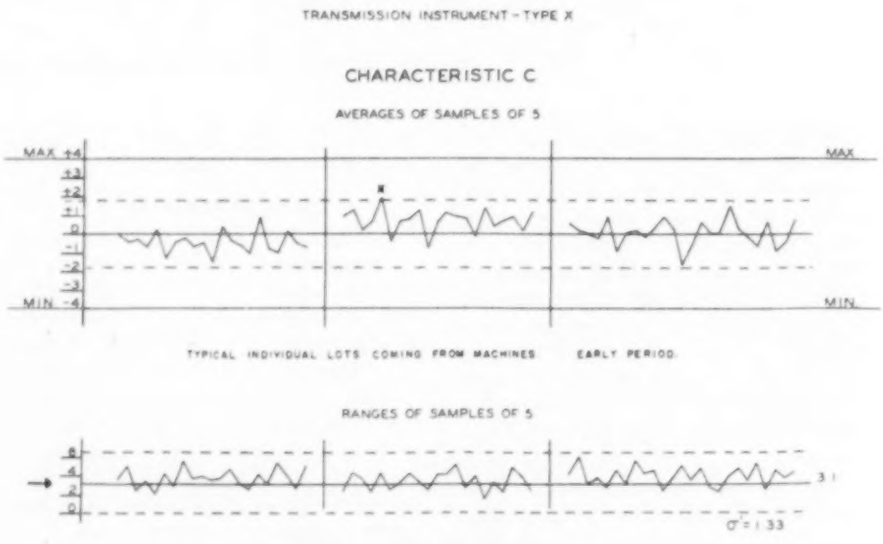

FIGURE 10—TYPICAL INDIVIDUAL LOTS

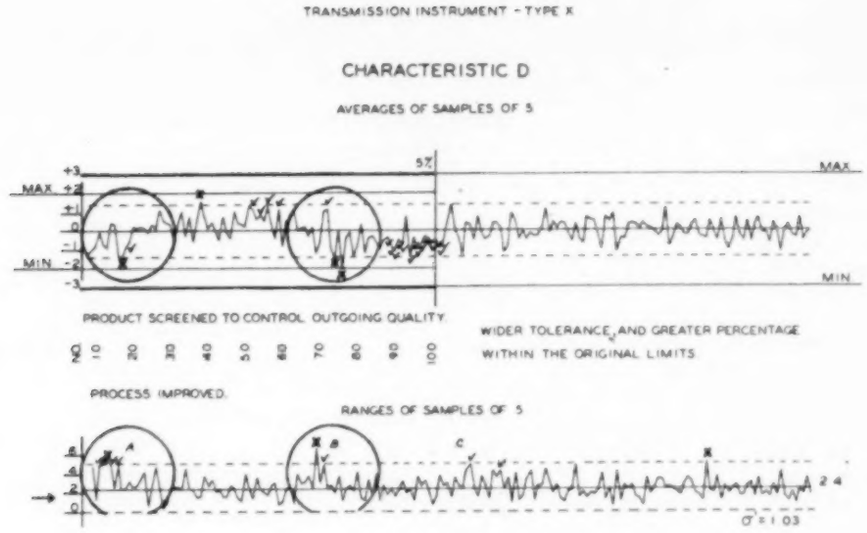

FIGURE 11—CHARACTERISTIC D

the percentage of nonconforming product.

This is a psychological effect which is often associated with higher percents defective, and which was not observable in the case of Characteristic C. As rejections become more frequent and disturbing, the mean is apt to become more difficult to hold; so that not only conformance, but statistical control itself, may depend in part upon a reasonable agreement between the process and the limits.

ADOPTION OF BROADER LIMITS

Now if we ignore the two high ranges at point B, which were due to a change in level between successive lots, we find that the pattern of variation in Figure 11 is quite stable and controlled. There was reason to believe that this might be the "natural" variability of the process, one which could not be reduced except by changes so fundamental that they would involve an unwarranted increase in cost. The so-called "natural tolerance" associated with this variability would have been ± 3 units instead of ± 2.

Limits of ± 3 were accordingly specified, at first on a temporary basis. From that point on the chart began to show an entirely different sort of control. The Shop actually produced a greater percentage of parts within the original limits than when those limits were in force; because now the process was allowed to operate with a minimum of interference, and its average was easily controlled around the specification mean.

In this case it required an auditing study, showing control of the variability of the total product, to convince the design engineers that the limits on this critical dimension could be broadened safely. They would not have been so readily convinced by a set of the usual control charts in the shop, covering the performance of individual machines, and showing different degrees of variability and control.

EFFECT ON OVERALL QUALITY LEVELS

An engineering study of this type may also be expected to have a beneficial effect on overall quality levels. In the case of transmission instruments this effect can usually be seen in the history of their electrical performance, as well as in the histories of individual parts.

Figure 12 shows the electrical performance of our instrument over the same period which was covered by the other charts. During this period one improvement after another took place internally, and one dimension after another was brought into a state of optimum control. It appears that a significant series of changes took place in performance also. Efficiency which was high to begin with became still higher; and at the same time the uniformity of the product was remarkably increased, as shown by a gradual reduction in the range. Product flowing to the field during the latter portion of this period is, from the point of view of the design, definitely better product than before. It exhibits less variation from unit to unit and from day to day. And because the entire process is known to be in adequate control, we can predict with considerable assurance that product like this will continue to flow from our conveyors for some time to come.

One word of explanation might be in order before we leave this chart. It will be noted that two sets of control limits have been shown: conformance-control limits near the specified minimum value, and regular statistical-control limits around the actual levels of performance. All of these limits have been based on the standard deviation obtained in the later period, in order to show the changes which have taken place. Points that are marked with crosses during the early portion were evidence of less complete control, but there was never any question as to the product's full conformance with the specification.

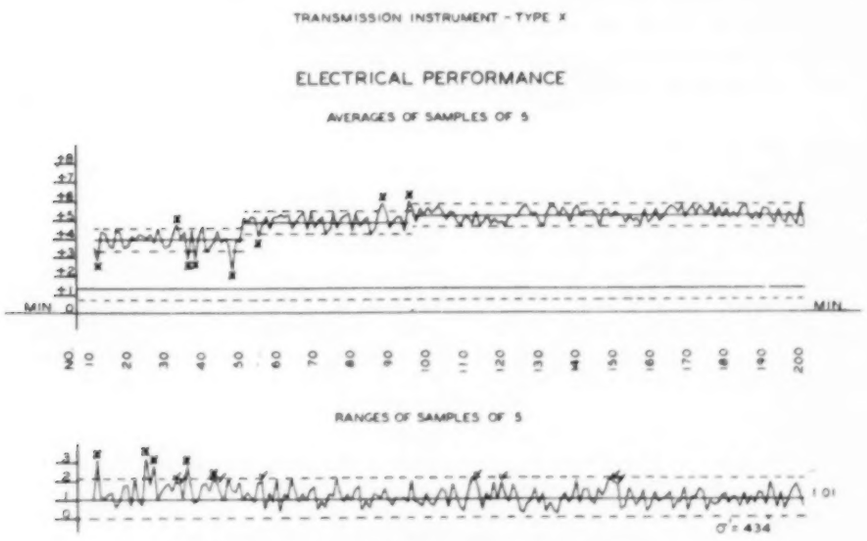

FIGURE 12—EFFECT ON OVERALL PERFORMANCE

NON-NORMAL DISTRIBUTIONS

Space does not permit us to discuss in any detail the technical problems involved in the setting up and use of control charts based on complex finished assemblies. But one particular word of caution may not be amiss. When we draw our samples from completed product it may be quite important to know something about the shape and character of the frequency distributions in that product. We may not be able to assume, as safely as in the more usual applications in the shop, that the distributions with which we have to deal are essentially normal or homogeneous.

This is a theoretical difficulty which has not been found to be too formidable in actual practice. If a distribution is characteristically skewed it may require a slight adjustment in the location of conformance-control limits. If large amounts of screening have been done by the Shop it may be necessary to supplement the chart with a more extensive study. And certain special precautions must be taken when, as sometimes happens, the product consists of a nonhomogeneous mixture of widely varying lots. In all such cases knowledge of the process and experience with the product are essential elements in the interpretation of the charts.

CHARACTERISTIC E: MIXTURES OF LOTS

Figure 13 gives an example of such a situation. Characteristic E is a dimension which has, in reality, shown good conformance-control throughout its history. All the apparent indications of lack of conformance on the chart—the crosses showing points outside of 3-sigma limits, and the checks representing improbable runs—are simply indications of the non-homogeneity of our data.

Characteristic E is found in product as a mixed population. Its specified limits are several times broader than the capabilities of individual machines or the normal spread of any individual lot. The limits are purposely made broad to allow for expected differences between the various lots, which result from a chemcial finishing process to which the pieces are subjected. The chemical process tends to shift the average of a lot without having an appreciable effect upon its spread. Since the Shop is not expected to keep these various groups separated from each other in assembly, they appear in product sometimes as single lots, and sometimes as mixtures of varying proportions.

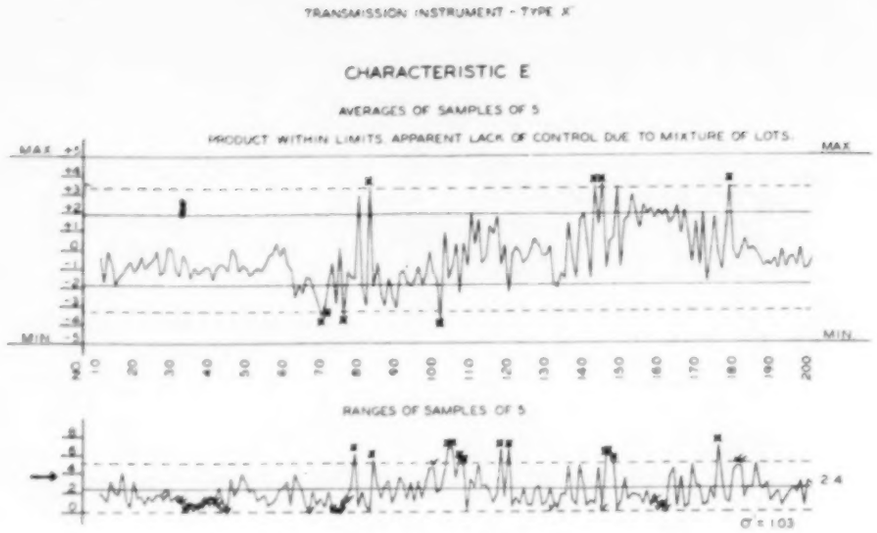

FIGURE 13--CHARACTERISTIC E

Samples drawn from such a changing population may show an extremely erratic series of variations. Note particularly the pronounced effect of mixture on the ranges in Figure 13. A chart like this may furnish useful information, but it should not, of course, be interpreted as evidence of a lack of conformance-control; and when such cases are encountered we may have to find some supplementary means of satisfying ourselves as to the conformance of the parts.

Figure 14 shows a series of frequency distributions of Characteristic E, from data taken at various times when the chart showed changes in the sub-universe. It is interesting to note that all of these varying distributions and mixtures add up to a total distribution which approaches the normal shape.

CONCLUSION

A control chart audit serves other useful purposes, which we can only mention here. It enables us to study conditions which cannot be checked in regular inspection, or which would not be economic to check on a shop routine basis. It acts as a safeguard against the effects of possible human errors, or faulty gages or equipment, which otherwise might creep into the finest system of inspection and control. It reinforces the basic inspection program, and in general guarantees a better outgoing quality than would have been obtained

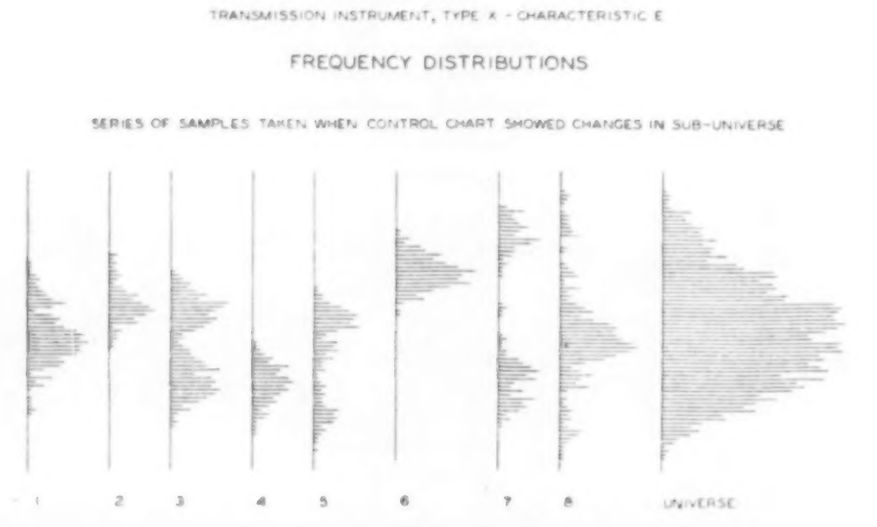

FIGURE 14—VARIATION FROM LOT TO LOT

by process controls alone.

We may summarize this application briefly as follows:

1. It has involved the use of control charts in making an engineering study of the quality of finished product.
2. Its purpose has been to verify the presence, in the product, of certain characteristics that were important from the engineering point of view.
3. In the accomplishment of this purpose it has had a direct and profound effect on the improvement of quality levels and the achievement of control.

REFERENCES AND NOTES

PART II

(1) W. A. Shewhart, "Economic Control of Quality of Manufactured Product," D. Van Nostrand Co., Inc., New York (1931).

(2) A.S.A. War Standard Z 1.3, "Control Chart Method of Controlling Quality during Production," Am. Stds. Assn., New York (1942).

(3) This type of chart is customarily referred to as a conformance-control chart in Bell System quality control work. When process variability (6σ) is smaller than the specified tolerance, the conformance-control limits (dotted lines) are usually placed inside the specified limits by an amount equal to $3\sigma - 3\sigma/\sqrt{n}$; and "product limits" (solid lines), representing acceptable levels for the product average, are placed inside the specified limits by an amount equal to 3σ. The dotted lines are similar to the "modified" control limits given by E. H. Sealy, "A First Guide to Quality Control for Engineers," Ministry of Supply, Advisory Service on Quality Control, C.P.R.S. D. (S.R. 17), London (Sept. 1943), except that the latter are placed inside the specified limits by an amount equal to $3.09\sigma - 1.96\sigma/\sqrt{n}$. When 6σ is equal to or greater than the specified tolerance, Bell System conformance - control limits are placed $3\sigma/\sqrt{n}$ on either side of the engineering mean.

(4) Simple non-parametric tests, and tests for unlikely extreme runs, are based on considerations similar to those discussed by E. L. Grant, "Statistical Quality Control," McGraw-Hill Book Co., Inc., New York and London (1946).

(5) H. F. Dodge and H. G. Romig, "Sampling Inspection Tables," John Wiley and Sons, Inc., New York (1944).

A New Method for Approving a Machine or Process Setting—Part II

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EDITOR'S NOTE

Part II in this issue continues the series begun by Professor Burr with Part I in the January 1949 issue. Part III, to conclude the series, will be published in the November 1949 issue.

INTRODUCTION

The preceding paper (Part I) discussed the case in which it is desirable to try to set at a precise level as closely as possible. This situation is typical when the specifications are relatively difficult for a process to meet, even when good statistical control is maintained. Thus, for example, if the drawing limits for an outside diameter are .4120", .4125", while the process standard deviation has been estimated to be approximately .000091" by use of $\bar{R}/d_2$, then it is clear that the setting should be close to .41225". In fact even if the setting were exactly at this value, then the $\pm 3\sigma'$ "natural tolerance" of the process would be $.41225" \pm 3(.000091)" =$ .41225" ± .000273" = .41198" and .41252". Since these do not quite lie within the specifications it will be necessary to try to keep the setting as close to the nominal as possible so as to minimize the number of out-of-tolerance pieces. In such a case as this, the technique of the previous paper would be applicable.

On the other hand, if the tolerance band is about eight or more times as great as the process standard deviation σ', then there is considerable possible latitude in setting. The choice as to where to set depends upon where it will be cheapest to operate. Thus if it is a matter of saving material, as in a loading operation, we may want to run as close to the lower specification as is safe. It might be desirable to set close to the high side in order to save in stock removal in grinding. Another common case is that in which, because of tool wear or chemical changes, it is desirable to start close to one specification and let the dimension or other measurement gradually change until it gets too close to the other specification. Figure 1 illustrates the situation. The main question on the initial setting is whether it is too low or not. If the initial setting is too high, we will merely have to reset unnecessarily soon. On the other hand, if the initial setting is too low there is danger of out-of-tolerance pieces. On the final setting, however, the situation is just reversed. The machine will be making some out-of-tolerance pieces if the setting is too high, but if we reset at too low a level we have merely lost a little additional running time. The present paper is designed for this one-way choice. The method would seem to have wide applicability to industrial problems with progressive change, such as tool wear or in those cases where danger lies only in one direction.

AN EXAMPLE

For a certain automatic producing a part called a "spacer," the outside diameter is subject to specifications of .1235" and .1250". The control chart for ranges shows good control with an

average range of .000276" for samples of five. Proceeding as usual to estimate the process standard deviation, σ', we have

$$\sigma' = \bar{R}/d_2 = 2.76/2.326 = 1.19,$$

where the unit has been changed to ten-thousandths of an inch. Multiplying by three we have $3\sigma' = 3.57$.

We can therefore say that it will be safe to let the automatic run until the process average has reached a level 3.6 tenths below the upper specification, and then it will be time to reset or redress the tool. On the other hand, it will not be safe to let the setting get much closer to the upper specification, .1250", than .12464" (.1250"—.00036"), because if it does we will be running some danger of pieces exceeding this specification. We therefore decide upon a convenient number just below .12464", say .1246" as a perfectly safe level at which to work. Then a point one-σ' above this would be the level at which we would want to be sure to reset; that is, at .1246" + .00012" = .12472". (In the present technique these two points are always one-σ' apart.)

As will be seen in Figure 2, the process average, .1246", is perfectly safe and we would always like to let the machine continue running for a time when it is working at this level. Since no sampling technique is absolutely sure, some risks must be taken. The present technique provides that if the machine is actually at the level of .1246", then only about one time in ten will we reach the undesirable decision of "reset." On the other hand if the level is checked when it is actually at .12472" and is therefore producing out-of-tolerance pieces about 1% of the time,* the decision will be to reset about nine times in ten.

In order to make the actual check on the setting a criteria table is constructed (see Table 1) and the measuring instrument is set to read in ten-thousandths of an inch, with .1246" reading zero on the scale. In order to make Table 1 it is only necessary to multiply each L and U entry of Table 2 by our σ' of .00012". The results are as shown in the Lσ' and Uσ' columns of Table 1.

Now when the automatic seems to be getting close to the run-out position, a check is made by placing the reading

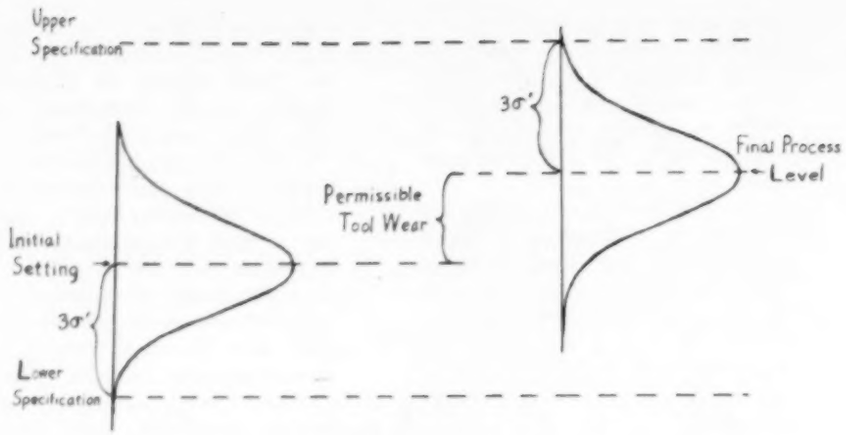

FIGURE 1 — DIAGRAM SHOWING AMOUNT BY WHICH PROCESS LEVEL MAY BE ALLOWED TO INCREASE FROM TOOL WEAR
(Outside diameter. A case in which the tolerance is approximately 8σ'.)

of each piece inspected in the column X. We record the number of "tenths" above (+) or below (—) in relation to the zero, which is .1246". The total is recorded in the ΣX column, taking careful and full account of the signs. Whenever ΣX goes above the respective Lσ' value the check has been completed with a decision of "reset." Or, whenever the ΣX is below the respective value of Uσ' in algebraic value, the decision is to let the automatic continue running. Thus, if after two spacers have been checked, the total is —2 (for example, by —1 and —1) then we would let the automatic continue to run.

Table 1 also shows data for a decision to let the automatic continue running, the total of —1 for three pieces lying below the respective Lσ' of —.8. On the other hand, the set of measurements —1, +3, +1, +2, +1, would have yielded the decision "reset," because the total of +6 is above the respective Uσ' of 5.6. In general, measurements are continued until either ΣX is above Uσ' or below Lσ'.

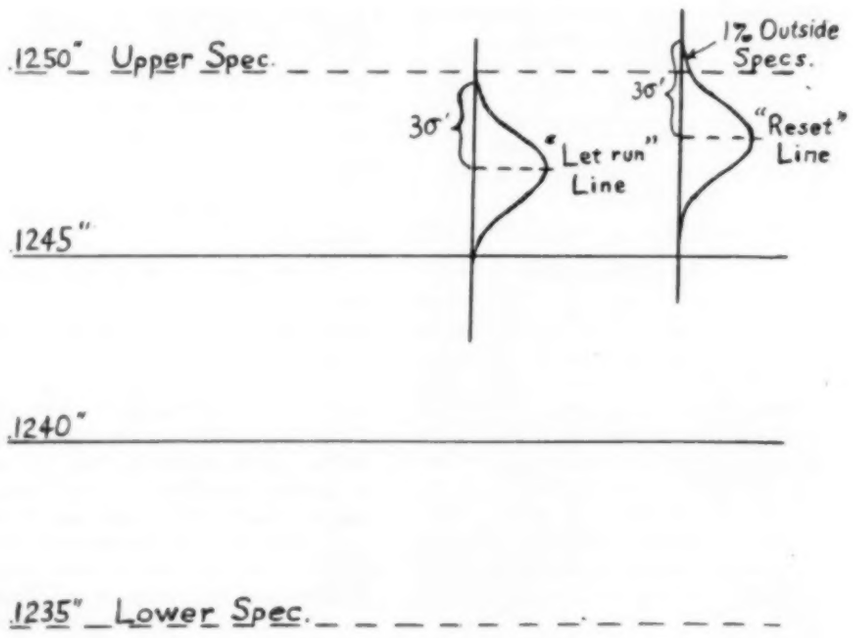

FIGURE 2 — SPECIFICATIONS FOR SPACER, AND NORMAL CURVES TO SHOW DISTRIBUTION OF PIECES AT CRITICAL LEVELS

* By the normal curve, using $t = (.1250" - .12472")/.00012" = 2.3$, so the area above .1250" is about .01.

Sample Size n	Lσ′	X	ΣX	Uσ′
1	—2.1*	0	0	3.2
2	—1.4	+1	+1	3.8
3	— .8	—2	—1	4.4
4	— .2			5.1*
5	.4			5.6
6	.9*			6.2
7	1.6			6.8
8	2.2			7.4
9	2.8			8.1*
10	3.4			8.6
11	3.9*			9.2
12	4.6			9.8
13	5.2			10.4
14	5.8			11.1*
15	6.4			11.6

TABLE 1

TABLE FOR CHECKING A SETTING WHEN $\sigma' = 1.2$ AND THE CHOICE IS ONE-WAY

(Data shown for a decision to let run.)

* The above entries are in reality closer to —2.0, 1.0, 4.0, 5.0, 8.0, 11.0, but these were rounded in such a way that there will be no question as to the decision. Thus for an n of 9, the figure for Uσ′ is 8.04. If this were listed as 8.0, then one would decide to reset on a total of 8 for 9 pieces, whereas the total of 8 does not exceed 8.04. Thus by recording 8.1 we can be sure that a decision to reset will not be reached on a total of 8, since 8 is still below the recorded 8.1.

Table 1 may also be used to check the initial setting. Starting at the lower specification of .1235" we go up 3σ′, that is, to .1235" plus .00036", or .12386". Now choosing an even ten-thousandth of an inch below this value we have .1238" as the lower critical level, which is too close to the lower specification. The desirable decision "reset at a higher level" will be reached about nine times in ten if the true setting is at .1238". On the other hand, .1238" plus σ′, or .12392", is clearly "safe" since it is over 3σ′ from the lower specification. The check will reach the decision for approval nine times in ten when the setting is at .12392". To check the initial setting using Table 1, we set the measuring instrument to read zero at .1238", and plus for larger diameters, as usual. Then continue to record measurements in the X column. The total ΣX is compared with Lσ′ and Uσ′. The only thing different here is that if ΣX lies below Lσ′ we reject the setting, while if above Uσ′ we approve the setting, since it is then toward the "safe" side. These decisions will be seen to be just opposite to those at the run-out side, precisely as one would expect.

It is to be noted that in this example the tolerance of .0015" is about 12.5σ′ and hence there is considerable room for tool wear; in fact about seven or eight "tenths."

Sample Size n	L	U
1	—1.70	2.70
2	—1.20	3.20
3	— .70	3.70
4	— .20	4.20
5	.30	4.70
6	.80	5.20
7	1.30	5.70
8	1.80	6.20
9	2.30	6.70
10	2.80	7.20
11	3.30	7.70
12	3.80	8.20
13	4.30	8.70
14	4.80	9.20
15	5.30	9.70

TABLE 2

CONSTANTS FOR CONSTRUCTION OF CRITERIA TABLE

(Ten percent risks; critical levels one-σ′ apart.)

OUTLINE OF PROCEDURE

The first requirement in using the present method for checking a setting is that the variability of the process should be stable; that is, a chart for ranges should have shown good control. Also, the distribution of measurements at any given time should be approximately normal. We then take the following steps:

1. Find σ′ by $\bar{R}/d_2$ and obtain 3σ′.

2a. For checking the setting at an upper specification, decide upon a "satisfactory" level about three or more σ′ below the upper specification. This is perhaps most easily accomplished by finding* USL—3σ′ and then taking the next whole number below this level, in the unit of measurement to be used. The "unsatisfactory" or "reset" level is one-σ′ higher than the "satisfactory" level.

2b. For checking the setting at a lower specification, decide upon an "unsatisfactory" or "reset" level less than 3σ′ above the lower specification. This is perhaps most easily accomplished by finding LSL+3σ′ and then taking the next whole number below this level, in the unit of measurement to be used. The "satisfactory" level is one-σ′ higher than the reset level.

3. Set the measuring instrument or scale to read zero at the satisfactory level for an upper specification or at the reset level for a lower specification. Larger measurements are positive; smaller are negative in both cases.

4. Multiply each value of L and U in Table 2 by σ′, expressed in the unit to be used in measuring, thus making a table like Table 1.

5. Begin taking measurements, carefully recording the signs whether positive or negative. Continue accumulating the sum, being careful of signs. Record in the ΣX column. Whenever ΣX lies above Uσ′ or below Lσ′ a decision has been reached.

6a. If checking at an upper specification, then ΣX lying above Uσ′ calls for "reset," while ΣX lying below Lσ′ calls for "approval."

6b. If checking at a lower specification, then ΣX lying above Uσ′ calls for "approval" while ΣX lying below Lσ′ calls for "reset."

7. The decisions in step 6 are so made that if the true process level is

* USL = Upper Specification Limit
LSL = Lower Specification Limit

exactly at one of the two critical levels, the chance of a wrong decision is one in ten. In general the decision will be reached after checking somewhere between two and eight pieces, although very rarely as many as fifteen are required. It is suggested that a reasonable practical decision be made if the procedure in 6 should happen not to have terminated after making fifteen measurements.

AN EXPERIMENT FOR PRACTICE

In order to get better acquainted with the technique shown here, the reader will find it highly desirable to try out the methods in an experiment. By use of dice such an experiment may be performed readily. It can easily be shown that when three or more dice are thrown, the distribution of the total points showing is approximately normal, and we have the following means and standard deviations:

No. of Dice	Average $\bar{X}'$	Std. Dev. σ'
3	10.5	2.96
4	14.0	3.42
5	17.5	3.82

We now regard 14 as a "satisfactory" level, which might be the case if, for example, 25 were the upper specification. Then, assuming that σ' for the process is 3.5, which is not too far from the truth in all three distributions, we have $17.5 = 14 + 3.5$ as the "reset" level. Next we build up the criteria table as in Table 3 by multiplying the respective entries of Table 2 by 3.5.

The three "measurements" shown in the X column correspond to totals of four dice as follows: 13, 15 and 9, which give —1, +1 and —5 after we subtract 14 from each. The decision is to leave the machine alone since the total of —5 is below —2.4. For totals of four dice the mean, $\bar{X}'$, is 14 and we should reach a decision of "leave the setting alone" about nine times in ten. The decision should be reached in about an average of three or four measurements, but may rarely require ten or more.

To illustrate the case in which the decision should be "reset" most of the time, we may throw five dice for each X. Since $\bar{X}'$ is 17.5 for this distribution we should expect a decision of "reset" nine times in ten. One such run was the following: 14, 18, 14, 20, 21, so that the X's were 0, +4, 0, +6, +7, the total of 17 just exceeding 16.4 and therefore calling for a decision of "reset." Again the average number of X's required is 3.5.

Sample Size n	$L\sigma'$	X	ΣX	$U\sigma'$
1	— 5.9	—1	—1	9.4
2	— 4.2	+1	0	11.2
3	— 2.4	—5	—5	12.9
4	— .7			14.7
5	1.1			16.4
6	2.8			18.2
7	4.6			19.9
8	6.3			21.7
9	8.1			23.4
10	9.8			25.2
11	11.6			26.9
12	13.3			28.7
13	15.1			30.4
14	16.8			32.2
15	18.6			33.9

TABLE 3
CRITERIA FOR DECISION WHEN $\sigma' = 3.5$
(Dice Experiment)

A case in which a decision of "leave the setting alone" should be quickly reached may be made by throwing three dice for a single X. Now since $\bar{X}'$

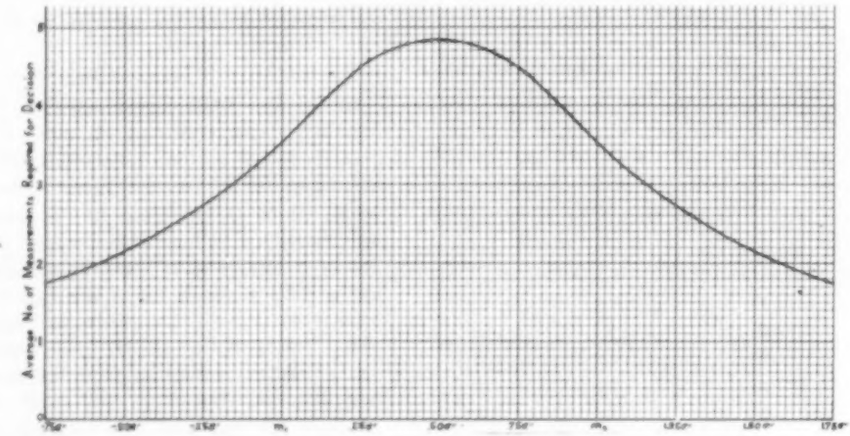

FIGURE 3 — AVERAGE SAMPLE NUMBER CURVE FOR THE CASE
$\alpha = \beta = .10$, $m_2 - m_1 = \sigma'$

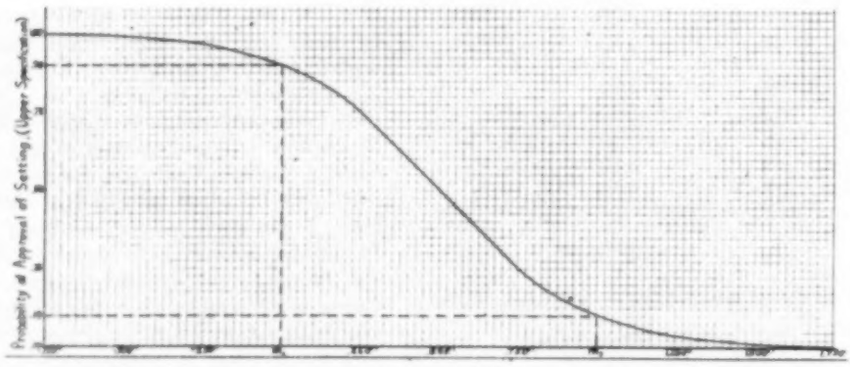

FIGURE 4 — OPERATING CHARACTERISTIC CURVE FOR THE CASE
$\alpha = \beta = .10$, $m_2 - m_1 = \sigma'$

is 10.5 it will require but an average of two X's for a decision. One run was 11 and 9, which give X's of —3 and —5. The total of —8 lying below —4.2 calls for a decision of "let run."

TECHNICAL APPENDIX

Following the usual notation in sequential analysis*, but continuing to use σ' for the process standard deviation, we have (Measuring scale is set to read zero at the lower critical level):

$m_1 = 0 \qquad m_2 = \sigma'$

$\alpha = .10 \qquad a = 2.197$

$\beta = .10 \qquad b = 2.197$

$$h_1 = b(\sigma')^2/(m_2 - m_1) = 2.197(\sigma')^2/\sigma' = 2.197\sigma'$$

$$h_2 = a(\sigma')^2/(m_2 - m_1) = 2.197\sigma'$$

$$s = (m_2 + m_1)/2 = .5\sigma'$$

Then if large values of $\bar{X}'$ are unsatisfactory the reject line value is:

$$\text{Reject } (\Sigma X) = h_2 + sn = 2.197\sigma' + .5\sigma' n = (2.20 + .5n)\sigma'$$

But this value we define to be $U\sigma'$, and hence U has the formula:

$$U = 2.20 + .5n$$

Also

$$\text{Accept } (\Sigma X) = -h_1 + sn = (-2.20 + .5n)\sigma' = L\sigma',$$

and hence

$$L = -2.20 + .5n.$$

The average amount of inspection before reaching a decision when the setting is actually at the level m_1 or m_2 is given by:

$$\text{Avg. Amt. of Inspection } \bar{n}\text{-at-}m_1 = 2[b(1-\alpha) - a\alpha](\sigma')^2/(m_2 - m_1)^2 = 2[2.197(.9) - 2.197(.1)](\sigma')^2/(\sigma')^2 = 3.52,$$

which also equals $\bar{n}$-at-m_2 since α and β are equal. Thus, when the setting is at one of the critical levels, then an average of three and a half measurements is required to reach a decision. Somewhat more than this number is required on the average if the actual process average lies between m_1 and m_2, and less if outside. These facts are shown in Figure 3. The calculations for these points are readily made, following formulas given in the reference already cited, Section 4. The points used were at intervals of $.25\sigma'$ from m_1. In this calculation we also obtain the values for the operating characteristic curve shown in Figure 4. Note that the probability of acceptance of a process average at m_2 is only .10 while that at m_1 is .90, in line with the risks assumed in the technique.

It is interesting to note that a single sampling plan supplying as nearly as possible the same protection as the sequential plan, requires seven measurements for a decision. It is the following:

1. Take seven measurements and find their average $\bar{X}$.
2. If $\bar{X}$ exceeds $.5\sigma'$ (the point half way between the two critical levels) we reject the setting. Otherwise it is approved.

As compared to the sequential plan, this plan has slightly lower risks of the wrong decision if the actual process level is at either of the critical levels, namely .093. This was the closest possible approach to .10 for α and β, since the sample size can only be a whole number. Note that even when the process level is at $.5\sigma'$ the sequential plan only requires about 4.8 measurements on the average for a decision, while this single plan would always require seven measurements even when the setting is far off and the decision should be easy.

* Statistical Research Group, Columbia University, *Sequential Analysis of Statistical Data: Applications*, Columbia University Press, New York, 1945.

ANNOUNCING THE

Fourth Midwest Quality Control Conference

HOTEL JEFFERSON, ST. LOUIS, MISSOURI

THURSDAY AND FRIDAY, NOVEMBER 10 AND 11, 1949

The eleven Midwest Sections of the American Society for Quality Control are holding their Fourth Midwest Quality Control Conference at the Hotel Jefferson in St. Louis on November 10 and 11, 1949. The Conference is being held in co-operation with Associated Industries of Missouri.

Program

Professor Irving W. Burr of Purdue University, Chairman of the Program and Speakers Committee, has secured an outstanding group of speakers for the clinical sessions, and experienced instructors in Quality Control for the training sessions. Featured on both days will be the luncheon sessions at which top-ranking executives will talk on Quality Control applications in their plants.

On the first day, Mr. Irl C. Martin, President of Woodward Governor Company, Rockford, Illinois, will be the luncheon speaker, while the second luncheon meeting will feature Mr. Charles E. Stines, Chief Inspector, National Cash Register Company, Dayton, Ohio.

Six training sessions, to be conducted largely on a classroom and laboratory basis, are planned to give basic instructions in the fundamental principles and techniques of control charts. These sessions will be directed by Messrs. Arthur Bender and George W. McDermott, both of Delco-Remy Division, General Motors Corp., Anderson, Indiana. They will have capable assistants to help them put the instruction on as nearly a person-to-person basis as possible.

Under the general chairmanship of Lester S. Kauffman, American Stove Company, St. Louis, the Planning Committee has set up an interesting and

well-balanced agenda for the two days, suitable to the needs of those who have no previous acquaintance with Quality Control as well as of those interested in the more advanced phases and techniques. Features of the Conference and the complete program follow.

Exhibits

As an important adjunct to the formal program, the Conference will feature exhibits of gages, calculators, testing equipment, and precision measuring instruments. The exhibits will be located on the Mezzanine, about which all Conference activity revolves, and will offer excellent opportunities for all to see the latest devices for measurement and control on display. Among the exhibitors are:

Bender Calculator Co.
Graham-Mintel Instrument Co.
Greenfield Tap and Die Corp.
Management Controls
Monroe Calculating Machine Co.
Sheffield Corporation

Abstracts

Abstracts of the clinic talks will be published prior to the Conference and will be furnished at no extra charge to those registered for the entire Conference. This publication will include the essentials of each talk, and will be useful in following the speakers, taking notes, and formulating questions for discussion. Additional copies of the abstracts will be available at a nominal charge.

Other Features

Thursday evening, November 10, will be reserved for Section meetings of the Midwest Quality Control Societies and for Committee meetings of the American Society for Quality Control.

On Friday morning, November 11, a breakfast for the officers and directors of all Sections will be held. The St. Louis Section, as host for the Conference, is handling the arrangements for this breakfast get-together.

Hotel Reservations

Reservations should be made directly with the Hotel Jefferson, 12th and Locust Sts., St. Louis 1, Missouri. When making reservations please refer to the Conference so that room assignments may be made from those reserved for Conference guests.

Registration

Advance reservation and registration forms have been sent to all Section Secretaries for distribution. Detailed Programs will be available early in October. The cost for a full two-day Conference ticket is $16.00. This includes both luncheon meetings, as well as all clinical **or** training sessions. Classroom material will be furnished at no extra charge. Requests for tickets must be accompanied by remittance in full, payable to the Fourth Midwest Quality Control Conference. Applications for tickets and requests for information should be addressed to the Secretary:

E. H. Sittner
2840 N. Spring Ave.
St. Louis 7, Mo.

Conference Slogan

GREATER QUANTITY
BETTER QUALITY
LOWER COST

CONFERENCE PROGRAM

Thursday, November 10, 1949

9:00 A.M.

Registration—Mezzanine

All members and guests attending the Conference or any of its sessions are requested to register at the Registration Desk on the Mezzanine immediately upon arrival, even though they may have made advance reservations and have their Conference tickets.

10:00 A.M.

Clinical Sessions

(1) Introductory Series
(2) Advanced Series

(1) SUBJECT: "Various Practical Applications of Quality Control"—First Session.
SPEAKER: Warren E. Jones, Senior Partner, Management Controls, Des Plaines, Ill.
MODERATOR: Henry J. Jacobson, Western Electric Co., Chicago, Illinois.

(2) SUBJECT: "Industrial Applications of Analysis of Variance."
SPEAKER: Guy G. Parkin, Director, Industrial Statistical Control, Minnesota Mining and Mfg. Co., St. Paul, Minn.
MODERATOR: H. S. Bicknell, Supervisor of Quality Control, The Maytag Co., Newton, Iowa.

Training Session

The first of six instruction sessions, featuring an introduction to Quality Control.
INSTRUCTORS: Arthur Bender and George W. McDermott, both of Delco-Remy Division, General Motors Corp., Anderson, Indiana.

12:00 Noon

Luncheon—Gold Room
SPEAKER: Irl C. Martin, President, Woodward Governor Company, Rockford, Illinois.
SUBJECT: "Quality Control—Another Production Tool."

2:30 P.M.

Clinical Sessions

(1) SUBJECT: "Air Transportation Finds New and Lucrative Uses for Statistical Quality Control."
SPEAKER: Dale L. Lobsinger, Staff Superintendent, Quality Control, United Airlines, Inc., Denver, Col.
MODERATOR: Wayne M. Biklen, Quality Control Engineer, W. A. Sheaffer Pen Co., Fort Madison, Iowa.

(2) SUBJECT: "Manufacturing Control of Soaps and Toiletries."
SPEAKER: Archie R. Jackson, Director of Quality Control, Allen B. Wrisley Co., Chicago, Illinois
MODERATOR: Irving W. Burr, Professor of Mathematics, Purdue University, West Lafayette, Indiana.

Training Session

Construction of $\bar{X}$ and R charts. Process out of control; process in control; use of Projected Limits.
INSTRUCTORS: Arthur Bender and George W. McDermott.

4:10 P.M.

Clinical Sessions

(1) SUBJECT: "Applications in Food Processing."
SPEAKER: Kenneth E. Moore, Manager, Materials Standards Dept., Campbell Soup Co., Chicago, Ill.
MODERATOR: Halmond L. Parks, Ball Brothers Co., Muncie, Indiana.

(2) SUBJECT: "Some Legal Aspects of Sampling."
SPEAKER: Frank R. Kennedy, Professor of Law, The State University of Iowa, Iowa City, Iowa.
MODERATOR: Paul K. Leatherman, Lambert Pharmacal Co., St. Louis, Mo.

Training Session

Construction of $\bar{X}$ and R charts with Modified limits.
INSTRUCTORS: Arthur Bender and George W. McDermott.

Friday, November 11, 1949

9:00 A.M.

Clinical Sessions

(1) SUBJECT: "Various Practical Applications of Quality Control"—Second Session.
SPEAKER: Warren E. Jones, Senior Partner, Management Controls, Des Plaines, Ill.
MODERATOR: B. E. Fike, Russell, Burdsall and Ward Bolt and Nut Co., Rock Falls, Ill.

(2) SUBJECT: "Fundamentals in the Design of Experiments."
SPEAKER: James A. Fizzell, Chief Product Engineer, Illinois Testing Laboratories, Inc., Chicago, Ill.
MODERATOR: A. R. Burgess, Acting Professor, Agricultural and Mechanical College of Texas, College Station, Texas.

Training Session
Calculation and meaning of Standard Deviation. Summary of $\bar{X}$ and R charts.
INSTRUCTORS: Arthur Bender and George W. McDermott.

10:30 A.M.
Clinical Sessions
(1) SUBJECT: "Building Quality Mindedness in the Carpet Industry."
SPEAKER: Albert G. Klock, Quality Control Superintendent, Bigelow-Sanford Carpet Co., Thompsonville, Connecticut.
MODERATOR: R. S. Saddoris, Director of Quality, A. O. Smith Corporation, Milwaukee, Wisconsin.
(2) SUBJECT: "Control of Visual Defects."
SPEAKER: Aldis S. Hayes, Quality Control Supervisor, Perfect Circle Corp., Hagerstown, Ind.
MODERATOR: John W. Meinhardt, Gaylord Container Corporation, St. Louis, Mo.

Training Session
Percent Defective Demonstration and construction of p charts.
INSTRUCTORS: Arthur Bender and George W. McDermott.

12:00 Noon
Luncheon—Gold Room
SPEAKER: Charles E. Stines, Chief Inspector, National Cash Register Co., Dayton, Ohio.
SUBJECT: "Quality Control at National Cash Register."

2:30 P.M.
Clinical Sessions
(1) SUBJECT: "Practical Applications in the Shoe Industry."
SPEAKER: Everett Wallace, Director of Quality Control, General Shoe Corp., Nashville, Tenn.
MODERATOR: William F. Kirschbaum, Jr., Navy Department, Fort Wayne, Indiana.
(2) SUBJECT: "A Simple Presentation of Quality Control Techniques and Their Applications in Diversified Industries."
SPEAKER: J. N. Berretoni, Consultant, Minneapolis, Minn.
MODERATOR: Donald J. Greb, Ass't. Chief Insp., Quality Control, Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

Training Session
Further work on p charts. Construction of c charts. General Review.
INSTRUCTORS: Arthur Bender and George W. McDermott

4:30 P.M.
Adjournment of Conference.

Practical Aids

ELLIS R. OTT, Editor

A Nomograph for Limit Lines on Measurement Charts

RAYMOND L. CLARK

ASSISTANT QUALITY CONTROL ENGINEER, KING-SEELEY CORPORATION

Prior to June 1948, control limits were placed on $\bar{X}$ and R charts at King-Seeley by direct arithmetical computation in each case. Sometimes, under the pressures of the hour, these calculations turned out to be incorrect.

In this article we shall describe a method, now in use at King-Seeley, which saves time and improves accuracy in placing control limits on average and range charts. The method consists of using a nomographic device such as is illustrated by the chart in Figure 1.

The distance from the center line to the control limits on an $\bar{X}$ chart, the distance from the center line to the 3-sigma limits for individuals for a process in control, and the distance from $R = 0$ to control limits on the range chart is in each case directly proportional to $\bar{R}$, being respectively $A_2\bar{R}$, $3\bar{R}/d_2$, and $D_4\bar{R}$, $D_3\bar{R}$.

Send your "Practical Aid" contribution to:
Dr. Ellis R. Ott, Rutgers University
77 Hamilton Street
New Brunswick, N. J.

For a process showing good control on the range chart and having wide specification limits relative to the natural tolerance of the process, it is often useful to operate under what are called "Reject Limits" or "Modified Control Limits." We prefer to call these modified limits "Upper and Lower Reject Lines," and to designate them as URL and LRL respectively. If we use USL for "upper specification limit" and LSL for "lower specification limit," then we have

$$URL = USL - (3\sigma - A_2\bar{R})$$
$$LRL = LSL + (3\sigma - A_2\bar{R}),$$

and the distance $3\sigma - A_2\bar{R}$ becomes important. A line showing how this distance varies with $\bar{R}$ can be drawn in an obvious manner once the lines for $A_2\bar{R}$ and 3σ have been plotted, and such a line is provided in Figure 1.

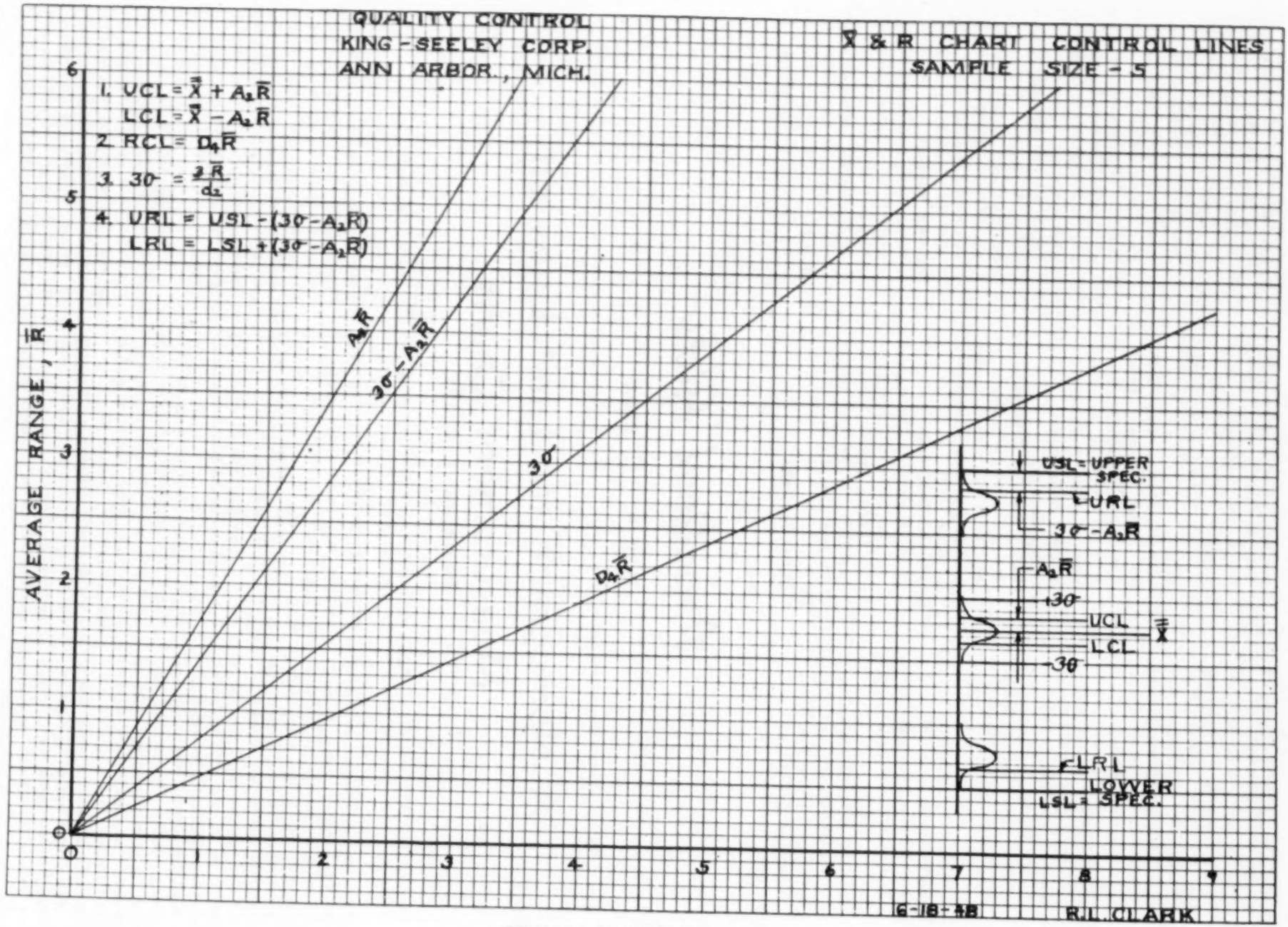

FIGURE 1 — NOMOGRAPH CHART

To summarize: the chart in Figure 1 shows four lines from which may be found

1. $\bar{\bar{X}}$CL (an $\bar{X}$ control limit): $\bar{\bar{X}} \pm A_2\bar{R}$;
2. RCL (upper control limit on ranges): $D_4\bar{R}$;
3. $3\sigma = 3\bar{R}/d_2$;
4. URL and LRL (upper and lower reject lines):
   URL = USL—(3σ—$A_2\bar{R}$) and
   LRL = LSL+(3σ—$A_2\bar{R}$).

The chart is based on the sample size n=5. Charts similar to this can be made readily for other values of n simply by using the appropriate values for A_2, D_4, (and in case n is greater than 6, D_3), and d_2. Since each of the left members of relations 1, 2 and 3 has the value zero when $\bar{R} = 0$, the chart may be constructed by merely selecting some convenient value for R, substituting it in the appropriate relation, plotting the corresponding point, and joining this point to the origin of coordinates by a straight line. For convenience in making and using the chart, the independent variable $\bar{R}$ has been assigned to the vertical axis and the same scale used on both the vertical and horizontal axes. The scale values are, of course, coded values, each unit on either axis representing one unit of whatever unit of measure applies to the chart application in question. The accuracy of the chart is sufficient for shop use.

To illustrate the use of this chart, suppose $n = 5$ and $\bar{R} = 3$. Locate $\bar{R} = 3$ on the vertical axis, read over to the $A_2\bar{R}$ line, and thence down to the horizontal axis to find 1.74. Then $\bar{\bar{X}}CL = \bar{\bar{X}} \pm 1.74$. Likewise, reading over on the line $\bar{R} = 3$ to the line $D_4\bar{R}$ and thence down to the horizontal axis, we find 6.33, so RCL = 6.33. Similarly, we find $3\sigma = 3.87$. Finally, using the 3σ—$A_2\bar{R}$ line, we obtain
URL = USL—2.13 and LRL = LSL+2.13.

Book Reviews

A. C. COHEN, JR., Editor

SELECTED TECHNIQUES OF STATISTICAL ANALYSIS

By the Statistical Research Group, Columbia University. Edited by Churchill Eisenhart, Millard W. Hastay, and W. Allen Wallis. McGraw-Hill Book Company, Inc., New York and London. 1947. 14 + 473 pages. $6.00. Review by Allen T. Craig, The University of Iowa.

This book is intended for all persons who have an interest in the increasing number of applications of modern statistical methods. It is not a handbook, but rather it seeks to explain the statistical approach and to indicate the limitations as well as the power of the techniques. The main text is divided into three parts. Part I is called "Industrial Statistics;" Part II is designated "Planning Experiments;" and Part III is listed as "Techniques and Tables."

Part I, which is longer than the other two parts combined, consists of six chapters. Chapter 1 (by W. Allen Wallis) treats the use of variables in acceptance sampling for percent defective, as opposed to inspection by attributes. The author gives in detail the plans of action, the amount of inspection required by the plans, and the operating characteristics of the plans. Numerous examples, together with adequate tables, make this a very readable chapter. Some knowledge of the non-central distribution would be helpful to the professional engineer. Chapter 2 (by Albert H. Bowker) is entitled "Tolerance Limits for the Normal Distribution." These tolerance limits are of the form $\bar{X} \pm Ks$ where $\bar{X}$ and s are sample estimates of the mean and standard deviation of a normal distribution, and K is a factor such that prior to drawing the random sample there is a preassigned probability that at least a fixed "proportion" of the normal distribution will be included between $\bar{X}$—Ks and $\bar{X}$+Ks. Rather extensive tables of values of K are given. The third chapter (by Harold Hotelling) presents some interesting and novel techniques in multivariate quality control, which he illustrates by the air testing of bombsights. The author's 1931 generalization of the Student Ratio is the spearhead of his attack on these problems, and the professional engineer may find parts of the chapter difficult reading. Chapter 4 (by Churchill Eisenhart) is a study of the effects of rounding or grouping experimental data. The author presents comparisons of the distributions of sample means, variances, and the Student t, for rounded and unrounded observations. Chapter 5 (by the Editors, based on a memorandum by M. A. Girshick) is entitled "Acceptance Inspection when Lot Quality is Measured by the Range." This treats the problem of controlling the difference between the largest and the smallest measurements in a random sample and seems particularly useful in situations where variability in time is involved. A single sampling solution and a sequential sampling solution are offered. Chapter 6 (by the Editors, based on material prepared by Myra Levine) presents two illustrative examples on the variability of the amount of inspection for various sampling plans which have nearly identical operating characteristic curves.

Part II, "Planning Experiments," opens with a chapter entitled "Planning and Analyzing Experiments for Comparing Two Percentages" (by Edward Paulson and W. A. Wallis). Here the problem is that of testing the homogeneity of a double dichotomy; that is, data from two sources wherein each datum is classified as "good" or "bad." Chapter 8 (by Eisenhart) considers the comparison of two standard deviations. Extensive tables are provided to facilitate a study of the operating characteristics of the procedures. An interesting set of

Correspondence and suggestions concerning book reviews should be sent to
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Department of Mathematics
University of Georgia
Athens, Ga.

technical notes on the accuracy of the tables is provided. Chapter 9 (by Milton Friedman) is concerned with two linearly related variables when the cost of a measurement depends upon the value of the dependent variable. In Chapter 10 (by the Editors, based on a memorandum by J. Wolfowitz) there is a study of the probability that a test will attain a specified severity. This study is followed by an investigation of the number of such tests that will be required for each item in order to realize a preassigned probability that at least one of the tests will be of the prescribed severity. Chapter 11 (by Friedman) deals with methods for estimating the mean and standard deviation of a normal distribution when the observations are actually taken on the integral of the normal function. In Chapter 12 (by the Editors, based on ideas and techniques due to L. J. Savage, K. J. Arnold, and M. A. Girshick) the authors introduce an interesting sequential technique into the design of an experiment which provides for the possible abandonment of the experiment before its completion if the usefulness of continuance seems doubtful. Chapter 13 (by Friedman and Savage) expresses some thoughts on the difficult problem of the experimental determination of the maximum of a function.

Chapter 14 (by Eisenhart) is the first chapter of Part III, "Techniques and Tables." Here is treated the risk involved in making a decision about the sign of the difference between two population means, when the decision is based upon the sign of the difference between the means of two random samples. Chapter 15 (by Eisenhart and Herbert Solomon) presents certain tests for the homogeneity of a set of variance estimates. The authors begin the chapter with a good exposition of the problems involved; they then discuss briefly the Bartlett test and, more elaborately, the Cochran test. We believe readers should give close attention to the section on the accompanying tables. The very effective inverse sine transformation of proportions is the subject of Chapter 16 (by Eisenhart). There is appended to that chapter a section devoted to the problem of a general transformation to stabilize variance, and several illustrative examples are included. The book closes with Chapter 17 (by Wallis) on "Elements of Sequential Analysis." The author outlines the general procedure, discusses certain advantages and disadvantages, and makes applications to the binomial distribution, the normal distribution, and double dichotomies.

At the end of each of the seventeen chapters is a valuable set of references, and the index is extensive and carefully prepared.

The foregoing remarks do not render full justice to the many excellent features of the book. There is such a variety of techniques that these remarks would exceed reasonable bounds were we to attempt too much in the way of detail. This reviewer found the book interesting and stimulating. He recommends it to the readers of this journal.

ANNUAL REPORTS

At the Annual Meeting of the Society in New York on 17 June 1949, the President, the Executive Secretary and the Treasurer presented Annual Reports on behalf of the Board of Directors. These reports were duly accepted. They have been extended to include the balance of the fiscal year, in accordance with the provisions of Sections 29. c. (3), 29. d. (5), and 33. h. of the Constitution, and are published in full below.

REPORT OF BOARD OF DIRECTORS

The Board of Directors of the American Society for Quality Control, Incorporated, presents herewith to the membership its third Annual Report, covering the fiscal year from 1 July 1948 through 30 June 1949. This report summarizes the principal activities of the Society during the year, more detailed information having been given in the issues of Industrial Quality Control which have been published in the course of the year.

Appended to this report are the Annual Reports of the Executive Secretary and of the Treasurer. The Executive Secretary's Report sets forth the status of the membership roll and the roll of Sections; the Treasurer's Report states the financial condition of the Society as of the close of the fiscal year. The Auditing Committee's certification of the Treasurer's Report is also appended.

Board of Directors' Meetings

Only one meeting of the Board was held during the year—in Boston on 5 May 1949. All of the Officers, 20 Directors, and 1 Alternate Director were present. Important action taken at this meeting included:

1. Confirmation of the action of the Executive Committee in recognizing the following as Sections of the Society:
   Cincinatti
   South Texas
2. Approval of the applications of the following for recognition as Sections of the Society:
   Muncie
   New Hampshire
3. Establishment of plan for accepting memberships from outside the United States and Canada only after individual approval by the Board of Directors or the Executive Committee. Renewal of present foreign memberships will also be submitted before further dues are accepted.
4. Acceptance and approval of the report of the Brumbaugh Award Committee, covering plans for the first Award and proposed Committee procedures and responsibilities.

Executive Committee Meetings

Three meetings of the Executive Committee were held during the year as follows:

Chicago—November 5-6, 1948
Rochester—February 15-16, 1949
Boston—May 6-7, 1949

All of these meetings were given over to general discussion and decisions with respect to Society activities and plans. Their proceedings have largely been reported in succeeding issues of Industrial Quality Control, and will not be repeated here.

In addition to these formal meetings, the officers have been in frequent consultation and discussion with other members of the Executive Committee

throughout the year in connection with important Society matters.

Sections Visited by President Wareham

During the past year, your President has addressed meetings in nine of the Sections of the Society:

Philadelphia
Southern Tier
Pittsburgh
Baltimore
Metropolitan
Syracuse
Delaware
Rochester
Ohio

In addition, he attended the Third Midwest Conference at Chicago in November and took part in the program of the National Convention of the Society in Boston.

Annual Meeting

The annual business meeting of the Society was held in New York City on 17 June 1949. The proceedings of the Annual Meeting are recorded in some detail in the American Society News section of this issue of Industrial Quality Control.

Officers elected for the fiscal year 1949-50 were as follows:

President: Ralph E. Wareham
Vice-President: Wade R. Weaver
Executive Secretary: Simon Collier
Treasurer: Alfred L. Davis

National Convention

The Third Convention of the Society was held in Boston on May 5 and 6, 1949, in conjunction with the Third New England Conference on Quality Control. The proceedings of the Convention were reported in the May 1949 issue of Industrial Quality Control, and no detailed report will be given here. Its outstanding success was largely due to the teamwork of the four New England Sections and to the hard work of the Convention Committees who played host to the Society.

Regional Meetings

Two large Regional Meetings were held during the year:

Midwest
Chicago, Ill.
November 4-5, 1948

Middle Atlantic
Princeton, N. J.
December 3-4, 1948

Each of these meetings was sponsored by all of the American Society Sections in its Region. In addition to luncheon and dinner sessions of a more general character, each meeting included a number of "clinical" sessions devoted to exposition of specific phases and applications of quality control. Both meetings were highly successful and contributed substantially to an increase in quality control enthusiasm in their respective Regions.

Section Meetings

All of the Society's thirty-five Sections held well-attended meetings more or less regularly during the year. Technical sessions were frequently preceded by a less formal dinner session. A number of Sections conducted highly successful quality control training courses just preceding the regular technical meetings.

Eight of the Sections also held all-day meetings with clinical sessions as follows:

Philadelphia and Delaware
Philadelphia, September 17, 1948
Iowa and Rock River Valley
Rockford, September 24-25, 1948
St. Louis
St. Louis, November 19, 1948
Rochester
Rochester, February 15, 1949
North Eastern Indiana
Fort Wayne, May 12, 1949
Michigan
Detroit, June 4, 1949

Section meetings constitute a substantial and important contribution to the life of the Society and to the benefit of individual members. It is to be hoped that these Section activities will increase in scope and strength with the continuing growth of the national organization.

Sections

Last year, the Board reported 31 Sections active in the Society. During this year, four new Sections have been recognized, so the Society now has 35 active Sections.

Membership

As a result of concerted work by the Membership Committee and by the members of the Executive Committee, there has been a substantial increase in Society membership during the year. At the end of the year, Society corporate membership was 2620 as compared with a total of 2092 at the beginning of the year—an increase of more than 25%.

An objective was set by the Executive Committee that one-half of the total membership would be in the Senior Member and Fellow grades. Actual accomplishment of 43% did not quite reach the goal.

Members-in-Training

During the year, the Board of Directors adopted By-Laws proposed by the Committee on Constitution and By-Laws covering Members-in-Training and Student Branches of the Society. Adoption of these By-Laws brings our Society policy in accord with that of other national engineering societies.

The principal provisions of these By-Laws were reported in the May issue of Industrial Quality Control. At the end of the year, 18 Members-in-Training had been enrolled under the provisions established by the new By-Laws.

Industrial Quality Control

The Editorial Board, under the able chairmanship of Professor Mason E. Wescott, has maintained the magazine on a 32-page basis throughout the year and has steadily improved its technical content. The appeal of the magazine to Libraries and other institutions has continued to expand.

The Industrial Quality Control News Supplement, under the able editorship of Ernest H. Robinson, has appeared throughout the year in those months when there is no issue of the magazine. A valuable feature of the Supplement has been the bi-monthly tabulation of future Section meetings.

Advertising

With the enlarged circulation of Industrial Quality Control, now well in excess of 2800, your Board of Directors is convinced that the magazine possesses real appeal to commercial advertisers and that such advertising should provide an important source of income for the Society.

During the year, the Executive Committee approved the President's appointment of Mr. Raymond S. Saddoris as Chairman of the Advertising Committee. Mr. Saddoris is working closely with representatives of each Section and hopes to increase total advertising substantially.

Work of Society Committees

During the year, the increasing activity of Society Committees has stimulated the work and activities of the Society. Each Standing, Technical, Special, or General Committee has carried on important work which has been of much assistance to the Officers in carrying through the Society Program. Recommendations of these committees, together with action taken, have been reported in previous issues of Industrial Quality Control and will not be repeated here.

The Society owes a debt of gratitude to each member who has served on our Committees to make the national program of maximum value to members.

Yearbook

The 1948-49 Yearbook was mailed to all acitve members in June. It included complete information on Society organization and committees, listed Society members alphabetically along with their Section affiliation, and included a catalogue of Section officers and their addresses.

Awards

At the Annual Convention in Boston, the first Shewhart Medal was presented to Colonel Leslie E. Simon of Aberdeen Proving Ground, Maryland, in recognition of his outstanding contributions in the field of modern quality control.

During the year, the Baard approved procedures for selection of the Shewhart Medalist and for making the Brumbaugh Award. These have been previously reported in Industrial Quality Control.

Sustaining Contributions

Additional contributions to the Shewhart Medal Fund during the year made possible the formal establishment of the Shewhart Medal and selection of the first Medalist.

The Society received a gift of $500 from the nine Midwest Sections from the proceeds of the Third Midwest Quality Control Conference, bringing to a total of $2000 the amount of such gifts from past Midwest Conferences.

Appreciation

The Board of Directors expresses its deep appreciation to all ASQC Committees and Committee Chairmen, to Section Officers, and to the members in general for the loyal and effective efforts which all have devoted to the advancement of the Society and its aims.

For the Board of Directors,

RALPH E. WAREHAM, President

New York City, June 30, 1949

REPORT OF THE EXECUTIVE SECRETARY

At the end of the Society's first fiscal year on June 30, 1947, there were 25 active Sections of the Society and a total membership of 1926, of which 243 had joined as Founding Members of the Society. During the 1947-48 fiscal year membership expanded to 2102 in 31 active Sections of the Society, one of which, the Rock River Valley Section, was recognized at the end of the fiscal year and did not enroll any national members directly until the 1948-49 fiscal year.

During the 1948-49 fiscal year the membership increased still further to a total of 2638, or 25% over 1947-48, and the number of active Sections increased to 35. New Sections recognized during the year were: Cincinnati, South Texas, Muncie, and New Hampshire.

The membership of the Society as of June 30, 1949 was composed as follows:

Fellows*	72
Senior Members	1073
Members	1475
Total membership	2620
Members-in-training	18
Total	2638

* Includes 2 Honorary Members

The attached Exhibit A shows the membership of the Society as of June 30, 1949 by Region and by Section, indicating the number of Fellows, Senior Members, and Members in each Section.

The Ohio Section, with 246 members, is the largest Section in the Society, and the Mid-West Region is the largest Region, with 757 members. The Baltimore Section, with a 200% increase in membership over 1947-48, has had the greatest rate of growth of those Sections with 50 members and under, and the N. E. Indiana Section, with a 93% increase, has had the greatest rate of growth of those Sections with over 50 members. The Central Region has shown the largest rate of Regional growth, with a 48% increase, and the Mid-West Region had the largest absolute growth, with an increase of 162 members. The Minnesota Section, with 100% renewal of their 1947-48 members, led the other Sections in that respect.

In October, 1948, we sent to the Section Officers and the Board of Directors a provisional Manual covering the relationship between the Sections and the office of the Executive Secretary, and we asked for suggestions as to changes that should be incorporated when putting this Manual into its final form. Special committees were set up for this purpose. At the May meeting of the Board of Directors in Boston, we were instructed to mail the Manual in final form during July, 1949 and we are happy to advise that this has been done. This Manual is the result of recommendations made by Section Officers, special committees, and members of the Board of Directors; it should materially help in the efficient administration of the Society.

As a result of the work of the special committee on appplication blanks a single sheet, two-page application blank has been prepared to replace the former two sheet, four-page form. This again is the result of the efforts of all concerned, and the new blank should enable all Sections to standardize on one application form.

The recognition of our Society by industry is becoming more and more noticeable as evidenced by the fact that we are receiving daily visitors and letters of inquiry pertaining to our activities. Careful attention to these requests will enhance the Society's reputation.

We wish to take this opportunity to thank everyone for the help that has been given us during the past year, for this has resulted in our making considerable progress. The steady growth of membership in the Society and interest in quality control since the formation of the Society in February, 1946, has been a constant source of encouragement to the officers and committees, and it is hoped that there will be a still larger growth of membership during the 1949-50 year.

Respectfully submitted,

SIMON COLLIER

Executive Secretary

New York City, August 5, 1949

EXHIBIT A

American Society for Quality Control, Inc.
Membership Report as of June 30, 1949

	Membership at June 30, 1948	Membership at June 30, 1949			
		Fellows	Senior Members	Members	Total
New England Region					
Boston	103	4	53	77	134
Hartford	36	0	13	28	41
Southern Connecticut	55	1	26	24	51
Western Massachusetts	47	1	30	17	48
TOTAL	241	6	122	146	274
Middle Atlantic Region					
Baltimore	13	1	7	31	39
Delaware	32	4	8	21	33
Metropolitan	148	15	90	79	184
Philadelphia	82	4	59	34	97
Washington	18	1	7	24	32
TOTAL	293	25	171	189	385
Northern Region					
Buffalo	82	1	23	52	76
Michigan	81	1	31	79	111
Mid-Hudson	28	0	7	18	25
Rochester	108	2	53	21	76
Southern Tier	55	0	13	44	57
Syracuse	95	4	35	73	112
Toronto	29	1	1	23	25
TOTAL	478	9	163	310	482
Central Region					
Cincinnati	0	0	7	6	13
Dayton	34	0	41	22	63
Georgia	25	1	22	9	32
Ohio	161	2	74	170	246
Pittsburgh	69	2	30	48	80
Tennessee	34	0	19	26	45
TOTAL	323	5	193	281	479
Mid-West Region					
Chicago	183	7	104	59	170
Illinois	28	2	12	6	20
Indianapolis	89	1	75	56	132
Iowa	89	5	43	53	101
Milwaukee	60	0	51	49	100
Minnesota	19	2	16	12	30
N. E. Indiana	42	1	4	76	81
Rock River Valley	0	0	4	10	14
St. Louis	85	3	34	53	90
South Texas	0	0	1	18	19
TOTAL	595	21	344	392	757
Western Region					
California	36	1	22	32	55
Members-at-Large	130	5	58	125	188
Members-in-Training	6			18	18
GRAND TOTALS	2,102	72	1,073	1,493	2,638

REPORT OF TREASURER

Appended hereto are Balance Sheet of the Society as of June 30, 1949 (Exhibit B), and Statement of Cash Receipts and Disbursements of the Society for the fiscal year July 1, 1948 through June 30, 1949, inclusive (Exhibit C).

Respectfully submitted,

ALFRED L. DAVIS Treasurer

Rochester, N. Y.

REPORT OF AUDITING COMMITTEE

With the approval of the Executive Committee, we retained Ernst & Ernst, Certified Public Accountants, to audit the books of the American Society for Quality Control, Inc. Relying on this audit and the certificate of Ernst & Ernst, we are of the opinion that the accompanying Balance Sheet and Statement of Receipts and Disbursements fairly present the financial position of the Society as of June 30, 1949, and its recorded cash transactions for the fiscal year ending that date.

Auditing Committee
HOWARD L. JONES
HOWARD L. BOLTON
G. RUPERT GAUSE
PAUL A. ROBERT
JOSEPH SADOWSKI

CERTIFICATE OF AUDIT

American Society for Quality Control, Incorporated.

We have examined the balance sheet of American Society for Quality Control, Incorporated as of June 30, 1949 and the statement of cash receipts and disbursements for the year then ended and, without making a detailed audit of the transactions, have examined or tested accounting records maintained by the Treasurer of the Society, and other supporting evidence as hereinafter outlined.

Cash on hand was counted and cash on deposit at June 30, 1949 was reconciled with amounts reported to us by Lincoln Rochester Trust Company. We traced the recorded cash receipts for the fiscal year to deposits shown by bank statements, inspected reports made by the Executive Secretary, for a period of three months selected by us, supporting amounts recorded as having been received for membership dues and tested other data on file supporting other recorded cash receipts. We also inspected canceled bank checks, invoices, and other data in support of the recorded disbursements for the year.

We examined data and checked computations supporting amounts shown in the balance sheet for accounts receivable, accounts payable and deferred income at June 30 1949.

In our opinion based upon our examination as outlined above the accompanying balance sheet and statement of cash receipts and disbursements present fairly the position of American Society for Quality Control, Incorporated at June 30, 1949 and the recorded cash transactions of the Society for the year then ended.

ERNST & ERNST

July 25, 1949, Buffalo, N. Y.

EXHIBIT B

AMERICAN SOCIETY FOR QUALITY CONTROL, INCORPORATED

Balance Sheet — June 30, 1949

Assets			
Cash:			
Current funds:			
On hand for deposit	$ 500.00		
Demand deposit	3,401.11		
Time deposit	1,666.64	$5,567.75	
Special funds—time deposits:			
Shewhart Medal Fund	$ 201.57		
Brumbaugh Award Fund	$1,005.00	1,206.57	$6,774.32
Accounts receivable:			
Advertising space in publication		$ 150.00	
Sale of back issues of publications and reprints		163.35	
Sale of Conference Papers		31.50	
Library subscriptions		37.00	381.85
Inventories—at nominal amounts:			
Back issues of publications, reprints and conference papers		$ 1.00	
Stationery and supplies		1.00	2.00
			$7,158.17
Liabilities and Surplus			
Accounts payable:			
For estimated cost of publication of 1948-1949 year book		$ 950.00	
For sundry expenses		306.17	
Income tax withheld from salaries		169.50	$1,425.67
Deferred income:			
Membership dues paid in advance		$ 324.00	
Estimated unearned portion of library subscriptions		403.74	727.74
Reserves:			
For Shewhart Medal Fund		$ 201.57	
For Brumbaugh Award Fund		1,005.00	1,206.57
Surplus			3,798.19
			$7,158.17

EXHIBIT C

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS

AMERICAN SOCIETY FOR QUALITY CONTROL, INCORPORATED

Year ended June 30, 1949

CURRENT FUNDS

Receipts:			
Membership dues:			
Members in training	$ 45.00		
Regular members	5,793.50		
Senior members	8,731.00		
Fellows	716.00		
Overpayments and dues received for prior period	207.88	$15,493.38	
Less refunds of overpayments		266.35	$15,227.03
Sustaining contribution			500.00
Publications:			
Advertising		$ 2,234.84	
Library subscriptions		1,242.08	
Sales of back issues		906.80	4,383.72
Sales of Conference Papers and other technical literature		$ 602.77	
Less amount remitted to sponsoring sections		245.23	357.54
Sales of emblem cuts and miscellaneous			22.54
Interest received on bank deposit			2.22
TOTAL RECEIPTS			$20,493.05
Disbursements:			
Publications:			
Publishing — magazine		$ 4,914.40	
Publishing — News Supplement		940.00	
Reprinting — back issues		266.47	
Mailing supplies and expense		687.25	
Postage		837.56	
Secretarial services		952.60	
Advertising commissions and cash discounts allowed		259.39	
Traveling expense		95.15	
Miscellaneous		124.67	9,077.49
Committees and Sections:			
Printing costs — public relations material, reprints, stationery, etc		$ 941.53	
Miscellaneous supplies and expense		18.59	
		$ 960.12	
Less reimbursed by Sections		761.50	198.62
President:			
Postage		$ 58.02	
Office supplies and expense		183.08	
Traveling expense		144.65	
Miscellaneous		182.68	568.43
Executive Secretary:			
Secretarial salaries		$ 4,054.99	
Printing and mimeographing		578.15	
1947-1948 Yearbook		1,864.95	
Postage		449.53	
Office supplies and expense		1,329.63	
Office rent		715.00	
Traveling expense		98.77	
Miscellaneous		176.62	9,267.64

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS — Cont'd.

Treasurer:		
Secretarial salaries	$ 1,337.10	
Postage	15.00	
Office supplies and expense	70.09	
Bond premium	25.00	
Bank collection and exchange fees	12.79	
Traveling expense	180.38	
Accounting service	200.00	$ 1,840.36
Transfer to Brumbaugh Award Fund		1,000.00
TOTAL DISBURSEMENTS		$21,952.54
CASH DISBURSEMENTS IN EXCESS OF CASH RECEIPTS		$ 1,459.49
Cash on deposit at July 1, 1948		7,027.24
Cash on hand and on deposit at June 30, 1949		$ 5,567.75

SPECIAL FUNDS

Shewhart Medal Fund:		
Receipts:		
Contributions received	$ 976.50	
Interest received on bank deposit	4.49	$ 980.99
Disbursements:		
For design, preparation of dies and striking of medal		1,664.42
CASH DISBURSEMENTS IN EXCESS OF CASH RECEIPTS		$ 683.43
Cash on deposit at July 1, 1948		885.00
Cash on deposit at June 30, 1949		$ 201.57
Brumbaugh Award Fund:		
Receipts:		
Transfer from current fund (from sustaining contributions made by Rochester Section in prior year)		$ 1,000.00
Interest received on bank deposit		5.00
Cash on deposit at June 30, 1949		$ 1,005.00

AMERICAN SOCIETY NEWS

ANNUAL MEETING—1949

The Third Annual Meeting of the American Society for Quality Control, Inc., was held in the Engineering Societies Building, New York City, on Friday evening, 17 June 1949.

President Wareham called the meeting to order at 8 p. m. and appointed:

Messrs. William A. MacCrehan, Jr.
Philip B. Proctor
David H. Schwartz
Charles J. Tantillo
Harry G. Romig, Chairman

to act as the Committee of Tellers for the election of officers for the coming year.

Executive Secretary Collier reported that 2585 postal ballots had been sent out to the membership and that 988 of these had been returned to him up to the time of the meeting. The President inquired whether any members present desired to cast their votes in person, and two additional ballots were collected by the Tellers. The Tellers received the mail ballots from the Executive Secretary and retired to make their tally.

The President then presented the Board of Directors' report on the progress and accomplishments of the Society during the 1949-50 fiscal year. Reports were also presented by the Executive Secretary and the Treasurer. Upon motion duly made and seconded, all of these reports were ordered accepted as submitted; they have been extended to include the balance of the fiscal year and are printed in full in this issue of the magazine.

The Committee of Tellers then presented its report to the meeting as follows:

Total Ballots Cast	990
Disqualified or Invalid Ballots	6
Qualified Ballots	984
Vote for President	
For Ralph E. Wareham	967
Not Voted	17
Vote for Vice-President	
For Wade R. Weaver	969
Not Voted	15
Vote for Executive Secretary	
For Simon Collier	975
Not Voted	9
Vote for Treasurer	
For Alfred L. Davis	973
Not Voted	11

The Chair then accepted the report of the Committee of Tellers and discharged them with the thanks of the Society. Messrs. Wareham, Weaver, Collier, and Davis each having received

a plurality of the valid ballots cast for the several offices were declared re-elected to the respective offices they had held since July 1, 1948.

There followed a lively discussion as to the best method for handling Society nominations for officers and of election procedure. Mr. Romig reported that a number of suggestions had been received with the ballots returned; he outlined to the meeting the key points listed in these suggestions. A number of constructive suggestions were made from the floor. It was decided that these suggestions, together with a written report by Mr. Romig, would be referred to the Executive Committee for thorough review and consideration.

Meeting was adjourned at 9:30 p. m.

N. I. C. B. REPORT ON QUALITY CONTROL

The National Industrial Conference Board has recently released an excellent report on "Quality Control Methods and Company Plans." Many members have already received copies of this report through the affiliation of their companies with the N. I. C. B.. President Wareham and Executive Secretary Collier, having assisted in the preparation of this report, it has been possible to arrange to secure copies of the report for members of ASQC desiring them—even though N.I.C.B. distribution is generally limited to its Members and Associates.

Any member desiring to purchase a copy of the report at the price of $1.00 should send his request and remittance to Mr. Simon Collier, Executive Secretary, at 22 East 40th Street, New York 16, N. Y.

TOLEDO SECTION RECOGNIZED

By mail ballot, the Executive Committee has voted to recognize the Toledo Section of ASQC as the thirty-sixth Section of the Society. Headquarters of the Section will be in Toledo, Ohio, and membership will be drawn from the large industrial area in and around Toledo.

1950 CONVENTION

The Society's Fourth Annual Convention will be held in Milwaukee on Thursday and Friday, June 1 and 2, 1950, in conjunction with the Fifth Midwest Quality Control Conference.

Arrangements have been made to hold the meetings in the Milwaukee Auditorium; committees are already at work to secure an outstanding program.

CLASSIFIED ADVERTISEMENTS

POSITIONS WANTED

QUALITY CONTROL ENGINEER desires position. Bachelor of Mechanical Engineering and Masters Degree in Industrial Engineering. Teaching and industrial experience. Member of ASQC—excellent references. Reply to 6B1, American Society for Quality Control, 22 East 40th Street, New York 16, N. Y.

COLLEGE GRADUATE with B. S. degree Industrial Management. Interested in Quality Control position. Two years inspection experience in electric meter mfg. firm. Member Society for Advancement of Management. Reply to Gerald R. Tapp, 7353 W. Estes Ave., Chicago 31, Ill.

QUALITY CONTROL ENGINEER desires position; A. B. degree Harvard University; two years experience in a large concern; member ASQC. Write D. H. Ransom, 43 School Street, Springfield, Mass.

CONFERENCE PAPERS

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Alfred L. Davis, Treasurer, ASQC
65 Plymouth Avenue South
Rochester 8, N. Y.

ABSTRACTS OF CONVENTION PAPERS

Third Annual ASQC Convention

$1.50 Postpaid

Prof W. A. MacCrehan,
New York University
New York 53, N. Y.

NOTICE

Send in your nomination for the first Brumbaugh Award before November 1, 1949. See p. 30, May IQC, for details.

CONSULTING SERVICES

Responsibility of the American Society for Quality Control, Inc., for Consulting Services advertising is limited to certification that advertisers hold the grade of membership in the Society stated in their advertisements. Qualification requirements for the several grades of membership are set forth in the Constitution of the Society.

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POSITIONS AVAILABLE

THE EMPIRE BOX CORP. wants two quality control engineers to set up and supervise quality control installations in their plants. One man will be located at Garfield, N. J.; the second will be located at South Bend, Ind. Experienced men with sound industrial inspection background are wanted, but experience need not be in the folding paper box field. The men selected will be required to organize their own depts. and to set up standards and testing techniques. Applicants may communicate directly with Mr. E. H. Robinson, Johnson & Johnson, Chicago, Ill. Furnish complete information covering formal education, industrial experience, and salary expected.

Quality Control and Consumer Representative; must have several years FACIAL TISSUE experience and knowledge of consumer research techniques. Plant located in central New Jersey. Write to 6H2, American Society for Quality Control, 22 East 40th Street, New York 16, N. Y.

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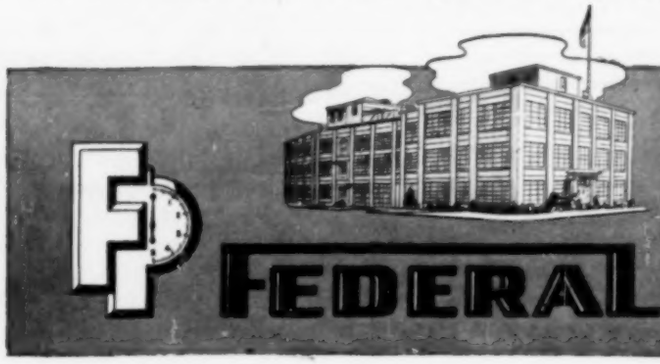

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